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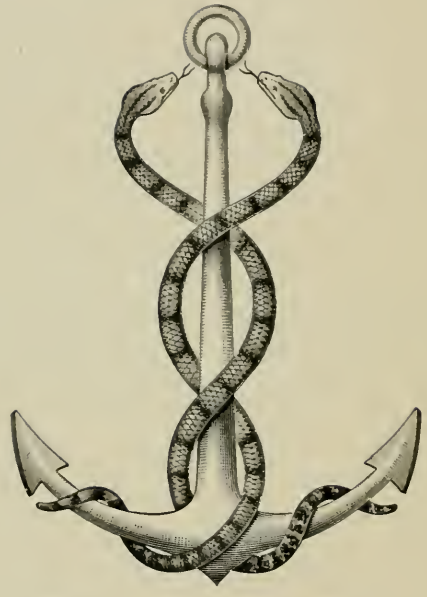

NUNQUAM ALIUD NATURA, ALIUD SAPIENTIA DICIT.

MANUAL

OF

PRACTICAL OPHTHALMOLOGY

BY

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WITH 223 ILLUSTRATIONS
MOSTLY FROM ORIGINAL DRAWINGS

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PREFACE.

Ophthalmology has long held a foremost place amongst the various branches of Medicine. In diagnosis, as well as in treatment, it had already attained to a high degree of precision at a time when modern scientific methods had as yet barely begun to foreshadow the results which they are now almost daily achieving in other departments.

Having thus early taken a leading position, the possibilities of further advance seem in the meantime to have been proportionately restricted. Coincident with the rapid strides made in surgery generally, and with the many discoveries which seem not unlikely to lead eventually to real therapeutic advances in internal medicine, Ophthalmology has practically been at a standstill.

This being so, and as there are already not a few text-books on diseases of the eye, an addition to their number can hardly claim to be called for because of the latest developments of the subject being either very extensive or very important.

A large experience as a teacher has, however, shown me that an adequate appreciation of the nature and treatment of even the commoner forms of eye disease is far from being general.

I venture to hope, therefore, that there may be room for a treatise which is both short and essentially practical, and which, while representing without unnecessary detail current opinions as to pathology, gives expression to the author's individual experience as regards diagnosis and treatment.

Edinburgh, *June* 1904.

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SECTION I.

DISEASES OF THE EYE.

CHAPTER I.

GENERAL REMARKS ON EYE OPERATIONS.

Operations are performed on the eye, or its appendages, with various objects in view. The most important, and, when successful, also the most satisfactory operations, are those which aim at the improvement, or at the prevention of any threatened deterioration, of vision. Some operations are performed solely or mainly for the relief of pain; others, again, seek to remove diseased conditions which endanger life, or to remedy deformities which entail danger to the eye, while some are mainly intended to have a cosmetic effect.

The following general remarks as to the precautions which should be taken in all cases will serve to obviate too much repetition.

All the instruments used in eye operations must be absolutely clean. They must not only be aseptic, but free from rust, blood stains, or any foreign matter. This applies most urgently to such as are, for any purpose, introduced into the eye. Any little piece of foreign matter, even though aseptic, if it becomes lodged within the eye, is capable of seriously impairing the success of an operation. Little bits of cotton or linen fibre may easily escape detection, and for this reason the instruments should not be rubbed with lint, cotton wool, or any material from which fine fibres might become detached. Instruments may be rendered aseptic in various ways, and it may not always be possible to adopt the same method. Some antiseptics, though sufficiently strong, spoil the steel, others are irritating to the eye. Boiling water, or a 5 per cent. solution of carbolic acid, are the most practically useful. If carbolic acid be employed,

the instruments must be transferred to some non-irritating solution before they are used. For this purpose boracic acid, in the strength of 1 to 50, is useful, or sterilised water alone.

Besides being clean and aseptic, it is of considerable importance to see that the cutting instruments—knives, scissors, needles, etc.—are sharp. A sharp instrument is a desideratum in most surgical operations, but it is very essential often to the success of an operation performed on the eye, as not only is the manipulation of a sharp instrument much easier, but the greater dragging, bruising, and stretching, which may be caused by blunt steel, is not favourable to healing by first intention, and may give rise to troublesome irritation. At the same time, as the vitality of the tissues is interfered with to a greater extent than in the case of clean-cut wounds, the danger of septic inoculation from any existing cause is increased. The points and edges of the knives should be tested immediately before they are used. This is best done with a little piece of thin kid leather kept tightly stretched by an assistant, or stretched across a small drum made for the purpose. To a sufficiently sharp point this should offer no appreciable resistance, and the keenness of the edge may be inferred from the ease with which the leather is cut by it. The resistance of point and cutting edge may be determined in grammes by means of the balance invented by Mr. Priestley Smith. A good cataract knife, for instance, should have a point which pierces the kid when the counter-weight stands at 1 grm., while every part of its cutting edge should not require more than 8 grms. pressure to pass through the drum (see Fig. 2). Scissors, besides being sharp, should have their blades sufficiently tightly screwed together to cut readily at the points.

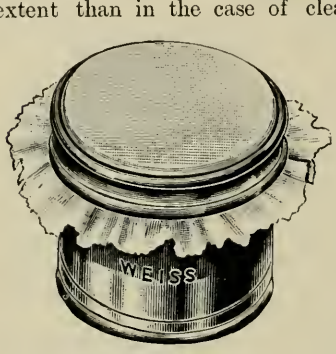
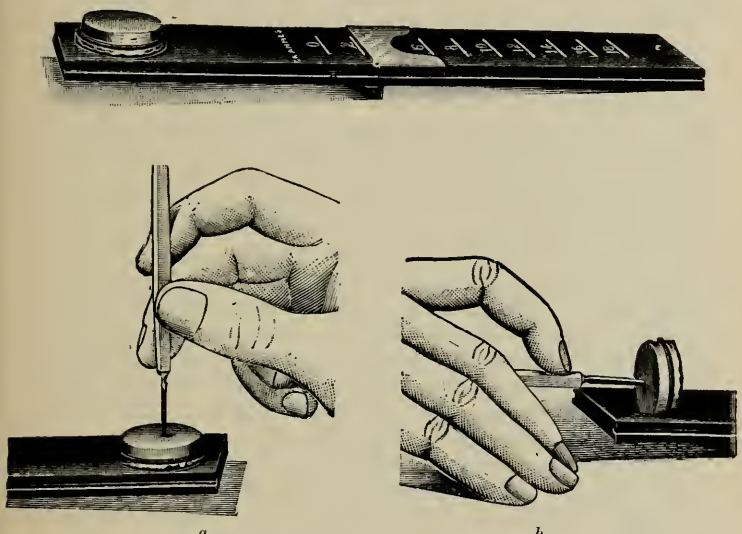


Fig. 1.—Drum for testing the points and cutting edges of eye instruments.

It is necessary to have a good light on the eye whilst operating. The table or couch must therefore be so placed that the operator and his assistants do not intercept the light, which should preferably come from one side alone. When artificial light is required, the rays from the source may be focussed on the eye by means of a large convex lens held by an assistant.

During an operation on the eye itself care must be taken that the patient's head is firmly held. With one hand of an assistant on either side of the head it may be securely fixed. Another plan, often adopted, is for an assistant on either side to hold one of the patient's ears, or the two ends of a cloth passed over his forehead.

Cocaine has in great measure done away with the employment of general anæsthesia in eye operations. The more important operations for the improvement of vision can now generally be



a. *b.*

FIG. 2.—Mr. Priestley Smith's balance.

a. Arrangement for testing point. | *b.* For testing cutting edge.

performed with the aid of cocaine, without causing any pain. A solution of hydrochlorate of cocaine, of a strength varying from 2 per cent. to 10 per cent., is used to drop into the conjunctival sac. The solution should be kept sterilised, or made up with some antiseptic, so as to obviate the possibility of introducing any micro-organisms into the eye. When the stronger solutions are used, the point of the finger should be pressed against the skin over the tear sac to prevent the cocaine passing down into the nose. The patient should be told to keep his eye closed after the drops have been applied. If this is not done, there is a

tendency to a rapid desiccation of the surface layers of the cornea, on account of the insensibility which the anæsthetic produces checking the normal blinking, and probably also the flow of the natural lubricants.

The value of *antiseptics* in eye operations is now so definitely established that it is inexcusable not to make use of them. Septic inoculations cannot invariably be avoided by such antiseptic precautions as it is possible to take, although their frequency can be greatly diminished. The reason of this is that the worst sources of danger are not external to the eye, but in the eye itself. The use of antiseptic applications in the manner about to be described, and the attention to absolute cleanliness and asepticity in the instruments, already insisted upon, is no doubt sufficient to prevent the possibility of infection from without. It is otherwise, however, with any micro-organisms which may be lodged in the conjunctival sac, or which may find their way into it from the tear passages. They cannot be destroyed with certainty, and the tying up of the eye even with an antiseptic bandage not only does not exclude them, but rather tends, owing to the retention of the secretions, to favour their development. In cases, therefore, where their existence is more than usually obvious, as where there is a chronic conjunctivitis or blennorrhœa of the sac, it is necessary to adopt special antiseptic precautions, and sometimes, if possible, to defer operating until there is reason to believe that such local sources of danger have been removed or mitigated. Often it is advisable to make a bacteriological examination of the conjunctival secretion before proceeding to operate.

The most useful antiseptics for local application are solutions of corrosive sublimate, and iodoform. The former is mostly used in the strength of 1 to 5000. In this dilution it is almost always found to be non-irritating, though cases do occasionally occur where some irritation is caused even by such a weak solution. According to bacteriologists, iodoform is a very poor antiseptic. No doubt this is the case, but it has the advantage of remaining longer *in situ*, and of, to some extent, acting as a cement between the lips of a wound, properties which, partly at all events, make up for its feebler antiseptic ones. A stronger non-irritating antiseptic of the same kind is a desideratum which has not yet been discovered.

Before performing any operation, the conjunctival sac should be thoroughly washed out with corrosive sublimate solution, and the surrounding skin, eyelashes, and eyebrows also carefully cleansed. From time to time, too, during an operation, the

lotion may be brought in contact with the eye, either by pouring it in a small stream from a narrow-necked bottle, or by squeezing it from a piece of absorbent cotton wool. The antiseptic lotion probably acts in two ways—first as a germicide, and secondly by washing away from the wound the secretions which contain the germs. It is not unlikely that the latter is its most efficient, perhaps indeed its only efficient, action. The methods of dressing are referred to in connection with the separate operations. Beyond the precautions referred to, namely, attention to asepticity of instruments and of anything brought in contact with the eye, and the use of frequent irrigation, nothing further is required in the way of antiseptics. Some few operators attach importance to operating in an aseptic, or supposed aseptic, atmosphere. To do this they take the most elaborate precautions in the arrangement of their operating rooms, use a special dress for operating, etc. Such precautions, however useful they may be in larger operations, are unnecessary in the case of eye operations. It is not possible in this way to get any further reduction in the number of inoculations than by a conscientious attention to the simple precautions against the real sources of danger, namely, the introduction of septic matter by the hands, lotions, or instruments, and the self-inoculation which may take place from the secretions of the conjunctiva and tear sac. In performing any operation, the operator's fingers should never be brought into direct contact with the eye. The speculum and fixation forceps render this unnecessary, and these instruments are easily made aseptic, whereas the fingers may, even with the best precautions, convey infectious matter.

CHAPTER II.

EXAMINATION OF THE EYE.

A SYSTEMATIC examination of the eye should be both subjective and objective. In the *subjective examination* the patient is first questioned as to any abnormal sensations which he may experience. Suitable tests are then applied in order to determine the degree of perfection with which the various visual functions are performed.

By the *objective examination* a more complete explanation may be found of the cause of any abnormalities which are revealed by subjective tests. Considerable experience is sometimes required to know how far the result of subjective examination is in accordance with, and can be explained by, what may be found objectively.

Both objective and subjective examinations should be made in a routine manner. This prevents any existing defects or abnormalities from being overlooked. On the whole it is advisable to complete the subjective, before proceeding to the objective, examination. But there are certain preliminary points in an objective examination to which attention should first be given. For instance, an inspection may first be rapidly made of the lids, conjunctiva, cornea, and iris. Then the state of the intra-ocular tension and of muscular equilibrium may be noted before the subjective examination is begun. After the visual acuity of each eye has been determined, and any other subjective test which may be considered necessary applied, the objective examination may be continued in the dark room, first by examining the cornea, iris, and anterior surface of the lens by oblique illumination, then by reflecting light with the ophthalmoscope into the eye to ascertain the transparency of the other dioptric media, and finally by obtaining an ophthalmoscopic image of the different parts of the back of the eye.

Preliminary Objective Examination.

By *inspection of the lids* we note any abnormality of the skin and of the cilia, also whether the puncta lachrymalia are rightly applied to the eye, or at all everted. The position of the lids with respect to the eyes should be noted. By causing the patient to move the eyes upwards and downwards, any abnormality in the lid movements may be detected. By placing the finger or thumb on the skin of the lower lid and slightly pulling it down, while the patient is directed to look up, the lower lid is everted, and the conjunctival surface brought into view. If this be normal in appearance, it is generally unnecessary to examine the inner surface of the upper lid, but should the lower be injected or inflamed, or should there be any affection of the cornea or history of any foreign body having struck the eye, the upper lid must also be everted. This is done by raising the lid with the thumb of the one hand applied to its outer surface, so as to cause the eyelashes to project forwards. The eyelashes are then grasped between the forefinger and thumb of the other hand, and the lid in this way pulled downwards and forwards, while the patient is told to look down. At the same time the skin below the first thumb, which is slightly raised from its former position, is pressed downwards. Finally, a movement of rotation upwards of the other holding the margin of the lid, is made round it as a fulcrum. This causes the conjunctival surface to spring into view, and the more completely the more the eye is directed downwards. A more thorough exposure of the whole of the retro-tarsal fold of the conjunctiva is sometimes necessary. This may be got by pressing down the upper part of the skin of the lid with a probe, whilst the lid is kept everted in the manner described.

Attention should also be paid to the condition of the *tear sac*, over which pressure may be made in order to see whether or not this causes any regurgitation to take place into the eye. The importance of this is explained in the chapter on diseases of the lachrymal apparatus.

Inspection of the cornea may be rendered difficult by the more or less convulsive closure of the lids. Under such circumstances the eye should be opened with the finger tips applied to the lid margins; or Desmarres' elevators (Fig. 3) may be used. This is advisable, *e.g.*, if there is danger of bursting an ulcerated cornea. One elevator is inserted carefully under each lid and the eye opened by drawing them apart, avoiding at the same time any pressure on the cornea.

When the patient is placed facing a window, any irregularity of the cornea is readily seen by the distorted image of the window reflected from the defective portion of the corneal surface. To observe this the patient is made to follow the examiner's finger as it is moved in different directions. By means of a specially constructed *corneal microscope* pathological changes in the cornea may be examined under a magnification of from ten to thirty diameters.

The *intra-ocular tension* may be tested by gently pressing the tips of the two forefingers on the eye through the upper lid, while the patient looks down. By alternately varying the degree of pressure of first the one and then the other on the eye, some idea is obtained of the resistance which it offers. Another way is to cause the patient to look up, and apply the tip of the forefinger of one hand directly to the conjunctiva of the globe below the cornea, making a slight tapping movement without altogether removing the finger from the eye. The significance

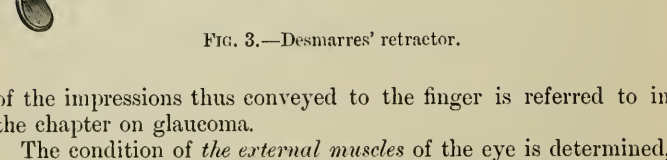


Fig. 3.—Desmarres' retractor.

of the impressions thus conveyed to the finger is referred to in the chapter on glaucoma.

The condition of *the external muscles* of the eye is determined, as far as is necessary for practical purposes, by causing the patient to fix a distant object alternately with either eye, whilst the observer's hand is held in front of the other, and by noticing whether any movement takes place, on removal of the hand, in the eye which has been occluded. If the eye be then moved inwards, there must have been a divergence, if outwards a convergence, of the axes when it was excluded from fixation.

Convergence is tested by causing the patient to fix a small object, which is gradually approached to his face, and then noticing the shortest distance up to which the two axes continue to be directed towards it.

Subjective Examinations.

Visual acuity.—One of the most important points to determine in all cases, and one which, whatever be the complaint of

the patient, should be tested as a matter of routine, is the degree of his visual acuity. This should be tested for each eye separately. The visual acuity is inversely proportional to the smallest visual angle under which two objects still give rise to distinct, separate, impressions. As the degree of absolute illumination is of influence on the acuity of vision, the ordinary test for the form sense should be made under a good illumination, such as is afforded by ordinary daylight or the light from a good gas burner placed close to, and reflected on to, the object serving as a test.

It has been found by experiment that two black objects on a white ground, if properly illuminated, can be seen by the normal eye as discrete when separated by a space which subtends an angle of 1′ with the eye. That is to say, if the visual angle (Fig. 4, A or B) is equal to 1′. This limit, though not in all cases the very lowest, is a suitable practical basis for the con-

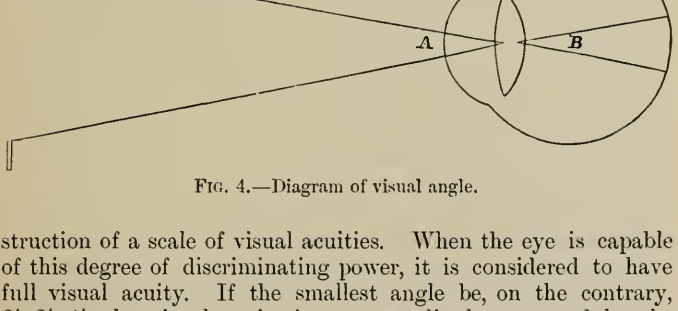


Fig. 4.—Diagram of visual angle.

struction of a scale of visual acuities. When the eye is capable of this degree of discriminating power, it is considered to have full visual acuity. If the smallest angle be, on the contrary, 2′, 3′, 4′, the visual acuity is correspondingly expressed by the fractions $\frac{1}{2}$, $\frac{1}{3}$, and $\frac{1}{4}$.

Various test objects, prepared according to the principle just explained, are in use for the practical determination of the acuteness of vision. That most commonly used is the set of test types known as *Snellen's test types*. These consist of a number of letters of the alphabet, or other figures, painted black on a white background. They are so formed that their height and breadth subtend angles of 5′, while the spaces separating those portions, which must be seen as discrete parts in order that the shape of the figure may be recognised, subtend angles of 1′ at the distances at which they should be read by anyone possessing normal visual acuity. A series of such letters or figures arranged in lines, the

letters in each line being the same size, while there is a difference in the size of those in consecutive lines, constitute the set of test types. Above each line is placed a number, which indicates in feet or metres the distance at which the letters should be read. The number of lines usually employed is seven. Of these the one containing the smallest letters ought to be recognised at 20 feet, and the others should with the same visual acuity be recognisable at 30, 40, 50, 70, 100, and 200 feet respectively. Other tables have the distances marked in metres, the smallest letters being recognisable at 6 metres, and the others at 9, 12, 18, 24, 36, and 60 metres respectively. The smallest letters are taken, therefore, of such a size that it is possible to place a patient at a distance from them which can be conveniently obtained in most consulting rooms. Where the room is considerably less than 20 ft., or 6 metres, in length, an additional line containing letters recognisable at 15 ft. may be added.

With the aid of Snellen's test types the degree of visual acuity can, with sufficient accuracy, be expressed as a fraction, the denominator of which is the number giving either in feet or metres the distance at which the smallest type legible by the patient ought to be read, and the numerator that which on the same scale indicates the distance at which the individual tested is placed from the test. Thus, if at 20 ft. distance the line marked 70, and which should therefore be recognised at 70 ft., can only just be made out, the acuity of vision (*Visus* or V) is $\frac{20}{70}$. If the patient has to approach 3 ft. nearer before being able to read that same line, V = $\frac{17}{70}$, and so on.

When none of the types are seen at 20 ft.,—that is, when (as the largest should be seen at 200 ft.) the vision is less than $\frac{20}{200}$, —the fraction expressing it may be found by approaching nearer and nearer to the types. If, for instance, the largest type, and that alone, were first recognisable at 5 ft., the acuity of vision in such a case would be represented by $\frac{5}{200}$.

In cases where the vision is very bad, it is customary to note the distance at which the outstretched fingers can be counted against the dark background of the examiner's coat, the result being noted as follows: V = fingers at 3 ft. or at 8 ft., as the case may be. When the vision is so far reduced that fingers cannot be counted even when close up to the eye, but yet the movements of the hand perceived, V is said to equal movements of the hand. This is often denoted thus: V = hand-reflex. When even this degree of acuity is not present, there may still be perception of light, or V = perception of light (or V = P.L.).

The main object in making the test of visual acuity is to ascertain the degree of acuteness of vision in any particular case at different times, either in the course of any disease, or with and without optical correction. This is for practical purposes sufficiently, accurately, and most rapidly determined by Snellen's test types, which have attained a popularity very much greater than other similar, and in most cases less accurate, tests. The average visual acuity of the normal eye diminishes with age. This is shown diagrammatically in Fig. 5.

Besides the acuity of vision, or the acuity of the sense of form, two other functions of the central portion of the retina sometimes call for investigation, namely, the colour vision and the sense of light, independently of form and colour.

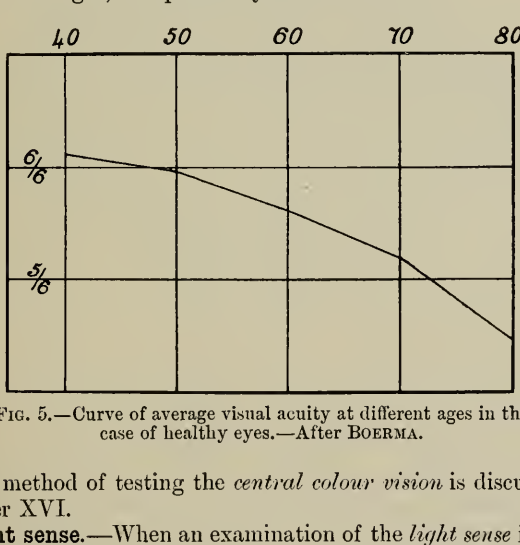


FIG. 5.—Curve of average visual acuity at different ages in the case of healthy eyes.—After BOERMA.

The method of testing the *central colour vision* is discussed in Chapter XVI.

Light sense.—When an examination of the *light sense* is made, it is necessary to gain information with respect to two different points—(1) The amount of illumination which is just sufficient to give rise to a sensation of light; and (2) the smallest difference between two intensities of illumination which is capable of being distinguished. It is difficult to make the examination in such a way as to clearly discriminate between pure sensations of light and mixed sensations of light and form. But in the examination of the light sense, as in all other subjective examinations, whatever their nature, our object is not to get mathematically accurate results, as that is impossible, but only

such for which the limits of error are not too wide for practical purposes.

A difficulty in connection with all methods for determining the minimum perceptible quantity of light (the *light minimum*) arises from the enormous degree to which that quantity varies, according to what is known as the state of adaptation of the retina. The sensitiveness to light is many hundred times less when the eye has been exposed for some time to strong daylight, than it is when it has been for some time (twenty minutes or longer) entirely kept in the dark. Practically, then, the unit must often be taken from a comparison with one's own light perception under the same conditions, and with proper care that the patient examined understands the nature of the test which is being made. Marked increase in the light minimum is pathognomonic of changes in the percipient elements of the retina, more particularly the hexagonal pigment cells.

Marked diminution in light difference perception characterises changes in the nerve elements of the retina and their central connections.

It is sufficient for practical purposes to recognise the abnormal manner in which the form sense is influenced by the conditions of illumination. It is a matter of experience that where the minimum perceptible degree of illumination is very appreciably greater than normal, a marked diminution in the visual acuity is found under an illumination which either does not at all affect, or it may be only slightly affects, the acuity of the normal eye. It is evident, too, that an eye which is very deficient in its appreciation of differences of intensity of illumination will be influenced in its visual acuity for objects the separate and distinguishable parts of which are not strongly contrasted in their relative luminosity. One of the simplest practical methods, then, of testing the first element of the light sense is to diminish the illumination until it just begins to affect the acuity of one's own (presumably normal) eye. An equally practical test for the second element exists in Bjerrum's test types, which consist of Snellen's types printed grey on grey. The contrast between the letters and the background is much less than for the ordinary types, which are printed black on white.

The vision of the peripheral portions of the retina may be defective with respect to all or any of the senses of form, colour, and light. As the nature of such defects often throws light on the diagnosis and prognosis of a case, the testing of the peripheral retinal functions takes an important place in the subjective examination of the eye.

Peripheral vision may be defective in continuity or in acuity. Often there is a defect in both respects at the same time, that is to say, that the most peripheral portions, where the normal acuity is least, may have their acuity reduced to 0, while the same cause of impairment reduces, but does not altogether abolish, the acuity of the more central portions. But besides regular interruptions in the continuity of the field of vision, which manifest themselves by some limitation, in the normal extent of the field in some particular direction, or in all directions, irregular breaches in continuity, or more or less blind

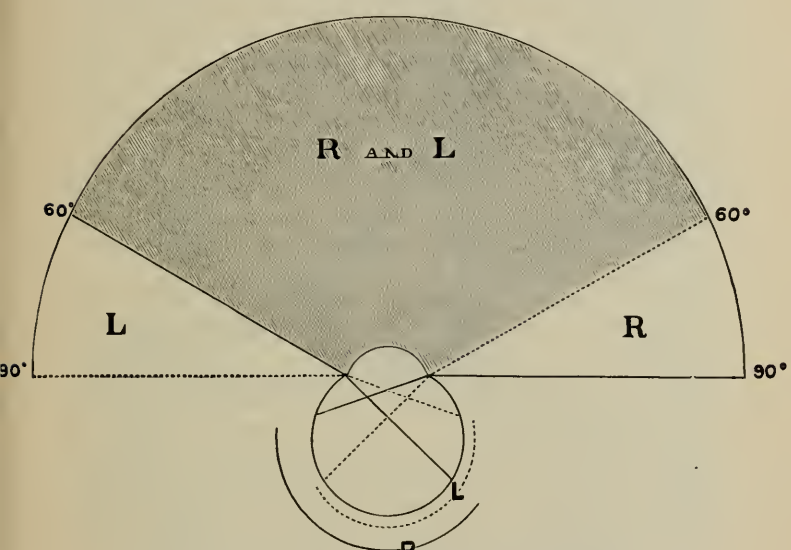


FIG. 6.—Diagram showing horizontal extent of field of vision.

portions surrounded by normal or relatively normal portions of the field, are met with, to which the name of *scotomata* has been given.

To make an accurate examination of the field of vision it is necessary to make use of some sort of perimeter. Such an examination takes some little time, and is only called for in certain cases. A rough examination, which is usually sufficient for the determination of any existing limitation in the peripheral boundaries of the field, should be made as much a matter of routine as the taking of the central visual acuity. It may be

made in the following manner. The patient is placed with his back to the light, and facing the observer. He is directed to cover one eye with his hand, and to fix steadily with the other the eye of the observer, which is directly opposite his own. Therefore, if the left be the one to be examined, the patient fixes with his left eye the right eye of the observer, whilst the observer at the same time fixes with his right eye the patient's left. In this position there is obviously a plane at right angles to the common line of fixation, and cutting that line at its mid-point, any point on which, provided rays from it enter the two eyes, will have an image at correspondingly situated points on the two retinæ. If, therefore, the observer, on moving his hand in any direction in this plane from or towards the middle of the line of fixation, finds that it disappears from or comes into his own and the patient's view simultaneously, it follows that their fields of vision are coextensive in that direction. A test in this manner can be rapidly made in all directions, and a want of coincidence of the two fields in any or all directions be easily discovered. This method of testing is only, however, a qualitative one in so far as by it the existence, and not the extent, of a limitation is determined.

For the purpose of obtaining more accurate measurements of the position and extent of any deviations from the normal character of the field of vision, as well as of estimating the peripheral visual acuity, a perimeter is required (Fig. 7). The result of a perimeter examination is most conveniently recorded on a chart, which consists of a number of concentric circles, the radii of which increase by an equal amount, and a number of radiating lines from their common centre. The circles, of which there are usually nine, represent at intervals of 10° the angular aperture of the field; the lines the different meridians. In the charts commonly used, the centre of the figure, therefore, corresponds to the point of fixation, whilst the concentric circles represent the portions of the field whose retinal images are equidistant in all directions from the fovea. If there be any doubt as to the restriction of the field in any particular case, the examination is best made in a subdued light, the intensity of which is a little greater than that which begins to tell on the normal field. This is a sort of compromise between the examination of the light and form senses which is of considerable practical importance.

The normal extent of the field of vision is subject to variation at its upper and also (though to a less extent) at its inner part, owing to individual peculiarities in the size and shape of the

eyebrows and nose. The physiological limits may be taken to be as follows:—Upwards, 45°; upwards and outwards, 50° to 55°; outwards, 90° (often slightly more); outwards and downwards, 80° to 85°; downwards, 70°; downwards and inwards, 60° (variable on account of the nose); inwards, 55° to 60°; inwards and upwards, 55°. The extent of the field upwards,

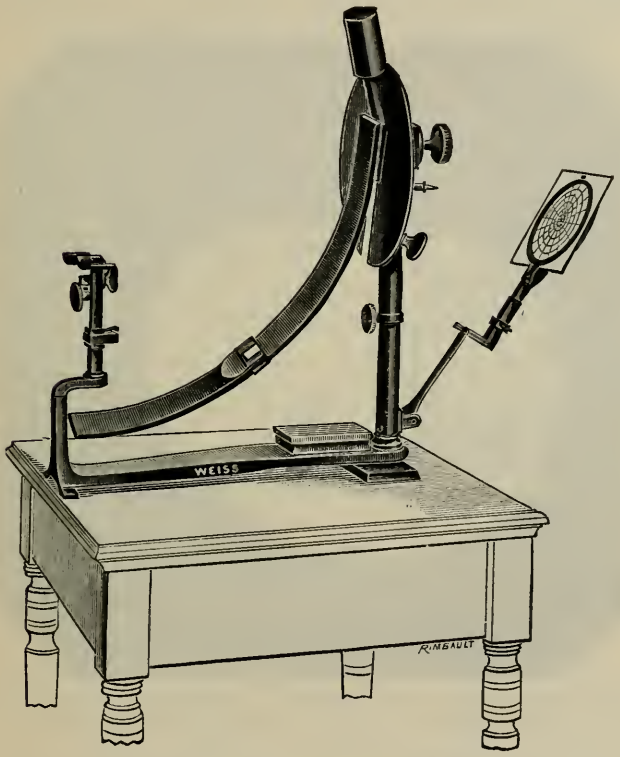


Fig. 7.—Self-registering perimeter.—M'Hardy.

and upwards and inwards, is found to be 5° to 15° greater when the point of fixation is situated 20° or 30° from the centre of the perimeter in the opposite direction. This has to be borne in mind when there is a doubt as to whether or not there is limitation in this region. Thus, should the exploration with the centre of the perimeter as point of fixation only give an angular

dimension of 40° for the peripheral extension of the field upwards, we should not always be right in assuming a contraction in this direction, unless no increased measurement resulted from testing with a lower point of fixation.

The maximum extent of the field of vision is only got for objects seen under a visual angle of $\frac{1}{2}$° and more. For smaller visual angles there is a gradual diminution in the size of the

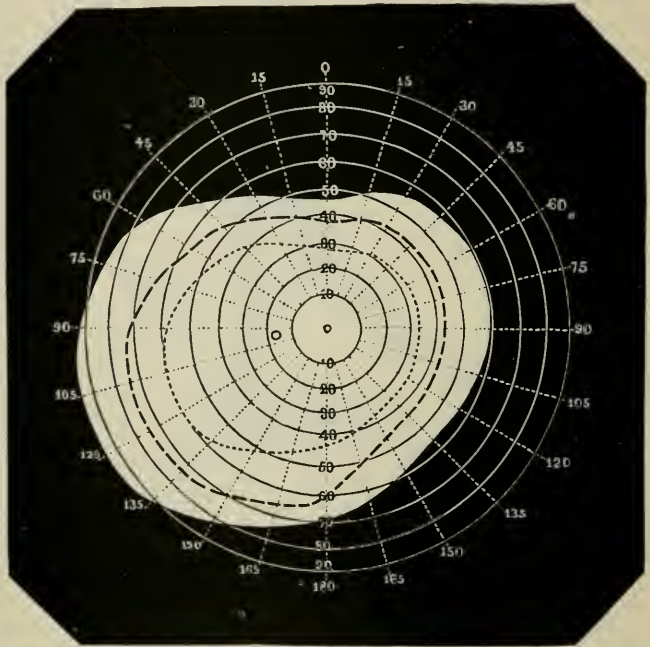


Fig. 8.—Perimeter chart of field of vision ; —— for white, ... for a red and complementary green, - - - for a blue and complementary yellow.

field. The test objects generally employed in perimetric measurements are from 1 to 2 cms. in diameter, which, at a distance of 30 cms., or about the radius of the perimeter arc, correspond to a visual angle of from 2° to 4°. Their images must, therefore, cover many thousands of retinal elements, so that the test is far from being a fine one, and not at all comparable to the tests made for direct vision.

A useful addition to the usual method of examining the

field of vision consists in making use of white objects which subtend a very small visual angle. In order, however, to be able to work without difficulty, with sufficiently small visual angles, it is necessary to have the patient placed some distance from the plane in which the test objects lie. A method of examination based on this principle was first adopted by Bjerrum, and is capable, in many cases, of affording data of considerable diagnostic importance. A large black screen, 2 metres or more broad, which can be let down from the ceiling to the floor, should be used—the screen is most conveniently placed on the wall opposite the space between the windows, so as to get good light all round. It has to be pretty large, as the projection of the blind spot at a distance of a couple of metres, instead of measuring about 1 in., as on an ordinary perimeter, where the distance of projection is 1 ft., or 30 cms., measures 7 in. in diameter, and everything else is, of course, in the same proportion. A screen, 2 metres broad, will admit of testing up to about 27° from the point of fixation, if that be in the middle of the screen, while, by removing the point of fixation to the edge of the screen, a larger field can be measured. When the test object is small, the central point of the screen can be used, and this, of course, is the most convenient arrangement. The test objects used by Bjerrum are small circular discs of ivory fixed on the end of a long dull black metal rod. They are of different sizes, from 10 mm. to 1 mm. in diameter. The examination is begun with a disc of 10 mm. diameter, at the ordinary distance (30 cms.), and afterwards continued in suitable cases with one 3 mm. in diameter, at the distance of 2 metres. In the first case the visual angle is $\frac{10}{300}$, in the second $\frac{3}{2000}$, or approximately 2° and 5 respectively.

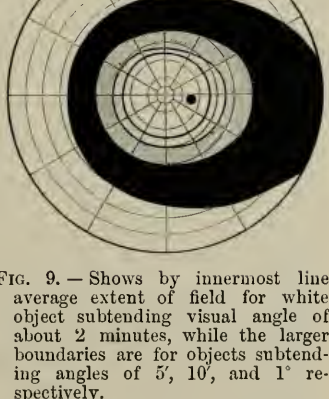


Fig. 9. — Shows by innermost line average extent of field for white object subtending visual angle of about 2 minutes, while the larger boundaries are for objects subtending angles of 5′, 10′, and 1° respectively.

In the case of the 5′ visual angle the boundaries of the normal field, instead of being as extensive as they are found to be by the ordinary method of examination (see p. 17), average 35° outwards, 30° inwards, 28° downwards, and 25° upwards. Too

much weight must not be attached to what appear to be slight concentric limitations got from an examination by the small visual angle method. It is the irregular limitations, the more or less sector-shaped defects and blind areas (scotomata), which are of the greatest importance. Concentric limitations are met with by this test as individual peculiarities. Under normal conditions, however, there are never found to be marked indentions or scotomata in the diminished field. Variations in illumination, it must be remembered, too, have a somewhat greater influence on the results got by testing with the small images than in the case of the ordinary perimetric method. The effect of tiring is also more noticeable than in tests made with the ordinary perimeter.

The most trustworthy test for peripheral visual acuity is that made with small objects at a distance by Bjerrum's screen test.

The determination of the *limits of the field for different colours* may be made with pieces of coloured paper. The results thus obtained are influenced by the hue and shade of the colour used, by the size of the coloured objects, and by the quality and intensity of the light under which the examination is conducted. Practically, in examining any case it is useful to determine the extent of one's own visual field in one or two directions under the same conditions, and then allow something for individual peculiarity besides. Another precaution that will be found useful is to have the test object (which it is well to make 20 mm. square) differently coloured on either side. In this way we are provided with a check on the accuracy of the patient's statements. The most convenient colour to use is some hue of red, as it is for the reds and greens that pathological defects in the colour sense first manifest themselves. When the red-green perception is entirely abolished, the limits may be taken for blue or yellow, the vision for which is almost always longer in disappearing; but the main necessity for this is to exclude the possibility of the more usual form of congenital colour blindness, which we should have reason to suspect if the peripheral boundaries for yellow and blue were not restricted.

Subjective Sensations.

The different subjective sensations which may be complained of, and for which a proper objective examination will afford a more or less satisfactory explanation in most cases, need only be shortly referred to in this chapter, as they are mentioned in connection with the diseases in which they are mostly mani-

fested. The principal ones are pain, double vision, distorted vision, the appearance of spots or clouds in front of the eye, and subjective light and colour sensations.

Pain.—Pain complained of in the eye may be non-inflammatory. It may also be primarily due to inflammation of the eye or the surrounding parts.

In a large proportion of the cases of pain unaccompanied by inflammation, the pain only comes on, or is at all severe, when the eyes are used for work near at hand, such as reading or sewing. In other cases, again, the pain is independent of the use of the eyes. The name which is generally given to the non-inflammatory pain associated with the use of the eyes is *asthenopia*, which literally means a want of power in the eye to perform its functions, and therefore an inability to sustain an effort which under ordinary conditions would not be appreciable.

Pain in the eyes, often described as at the back of the eyes, unconnected with any accommodative or muscular abnormality, and coming on, often very severely, at longer or shorter intervals after use of the eyes for reading, etc., is extremely common. Often the condition is associated with more or less sensitiveness to light. In many, and indeed most, of these cases there is absolutely nothing to be found, in connection with the eyes at anyrate, to account for the persistence or severity of the symptoms. Either the strain on the attention becomes soon too overpowering, or the retina itself is over-sensitive and easily tired. Some weakness exists in the tone or capabilities of the nervous mechanism of vision. Such a state of *nervous asthenopia* is probably frequently of reflex origin, though the region from which the afferent stimulus proceeds is not often apparent.

Many cases of retinal or nervous asthenopia are amongst the most severe and rebellious that one is called upon to treat. Cold water douches, and iron internally, are indicated in some cases; others are much benefited by hot sponging or fomentations; and where there is absolutely nothing abnormal to be discovered in the eyes, an energetic attempt should be made to break the habit of giving up reading as soon as the pain comes on. This can only be done gradually, but is successful in many cases.

Pain, independent of the use of the eyes, is often complained of, and is generally of a neuralgic character, and more or less intense. The diagnosis is easily made when there are points of special tenderness around the eye. Occasionally, no doubt, the pain is reflex, but the origin of most cases is an over-sensitiveness of the supra- and infra-orbital branches of the fifth nerve, generally caused originally by exposure to cold.

When the pain is due to inflammation, the diagnosis is often aided by noting the circumstances under which it is most intense. Thus sometimes it comes on mostly at night, at other times mostly when light falls into the eye, or when the eye is moved in some particular direction, or by pressure on some parts of the eye itself, or of the surrounding structures.

Diplopia.—When double vision is complained of, we have, in the first place, to determine, by covering first the one eye and then the other, whether in either case it is still present, or whether it always disappears when one eye alone is used; that is to say, whether the diplopia is uniocular or binocular. If there is a fair amount of vision in both eyes, and no abnormal degree of mental suppression of the image falling on the misdirected eye, there will usually be binocular diplopia when both axes are not simultaneously directed on the same point of the object which engages the attention. There may be no diplopia complained of even though there be wide divergence of the visual axes, owing to the unconscious mental suppression of the image of the one eye when the other is used for fixation. This suppression is sometimes so complete, that under no circumstances can the diplopia be made apparent. In other cases, by holding a red glass or a prism with the angle directed upwards or downwards in front of the fixing eye, the faulty image of the other is at once seen, showing that the suppression is only effected for normal conditions of similarity in the optical images or only for a retinal area, on which, under ordinary circumstances, the images corresponding to those occupying the centre of the retina of the fixing eye are received.

Again, an individual may complain of diplopia even although the visual axes are capable of crossing, and actually do cross, on the same object. This is the case when other objects than the one fixed engage the attention, and is, in fact, physiological, in so far as most objects not directly looked at are seen double. When, therefore, this kind of double vision is complained of, it is owing to an abnormal degree of attention being directed to objects other than those fixed. Usually there is a suppression of one of the images of other objects than the one on which the visual axes are directed—a suppression which is often so complete as to render it difficult for many people to become conscious of this physiological diplopia.

Which eye is the one whose images are suppressed in any particular case may be determined by a very simple experiment. By asking anyone, while keeping both eyes open, to hold up their finger in a line with some distant object, and then close first the

one and then the other eye, they will generally find that the finger exactly covers the object as seen by one eye, while it deviates to one side when looked at with the other. This shows that only the image formed in the eye, in a line with which and the distant object, the finger has been placed, is observed, that in the other being more or less completely suppressed.

The cases of diplopia just referred to are due to the opposite condition, namely, to a too ready appreciation of the physiological double images. This is mostly met with in women, but occasionally also in men. When once discovered by them, and not recognised as physiological, they contract a habit of directing attention to the double images which sometimes becomes almost painful. Occasionally it is the nose which is in this way brought prominently before their notice, and which always appears to get in the way of other objects, by attracting attention at the same time; at other times, any objects, both beyond and nearer than the point of fixation, are continually forcing their two images on the attention.

The manner of testing for binocular diplopia, as well as the interpretation of the results thus obtained, is fully discussed in the chapter on muscular anomalies.

When the diplopia complained of is found, in the way already described above, to be uniocular, the cause will generally be some error of refraction which has long existed or has been lately acquired, and a careful examination will be necessary to discover it. We have first to find out whether the diplopia has suddenly made its appearance or not. If so, it may either be due to some trauma, or the conditions giving rise to it may have previously existed, and only be observed owing to some circumstance which has caused the patient's attention to be directed to it. If there has been a trauma, we may look for irregular astigmatism, or some refractive changes, due to alteration in the position or condition of the lens, etc. The most common causes of acquired uniocular diplopia are changes sometimes occurring in the lens during the formation of cataract, and alteration of the curvature of the cornea produced by inflammatory changes.

When not due to a trauma, the doubling of the image in one eye, hitherto existing, though unobserved, may sometimes suddenly force itself on the attention, either owing to increased retinal susceptibility to impressions, or to some cause having temporarily disabled the other eye; and when once discovered it may become more or less troublesome. In this way we sometimes find uniocular existing along with binocular diplopia, the

former being first brought to notice by the occurrence of the latter.

Metamorphopsia.—When distorted vision, or metamorphopsia, is complained of, it should suggest either some cause altering the character of the impressions formed on the retina, as, for instance, irregular astigmatism, or some pathological change which interferes with the normal manner in which our judgment of the shape of objects seen is formed. The apparent shape of objects depends, in the first place, on the configuration of their retinal images; it is therefore more in accordance with their actual shape the more regular is the refraction of the rays through the dioptric media of the eye, and the more accurately the rays are focussed on the retina. For the correct appreciation of form it is further necessary that the percipient elements of the retina should be grouped according to their normal arrangement in the focal surface of the eye, and should all be capable of excitation to some extent at least.

Of the size of objects, again, we judge partly from the size of their retinal images, but as this, besides depending on the actual size of the objects, depends also on their distance from the eyes, the appreciation of size is more correct the more accurately the distance is gauged. In comparing the sizes of two or more objects, we are probably guided by the appreciation of their retinal images alone, if they are small. When of any considerable size, however, the method of comparison is more complicated, and depends chiefly upon the knowledge gained by the sense of muscular innervation on running the eyes along over the different points of the objects.

Defects of accommodation give rise to alterations in apparent size, owing to the error in the judgment of the distance of objects (within the ordinary range of accommodation) which results from them. Thus, where all at once there is a paresis of accommodation, and a greater effort has to be made in order to focus a near object distinctly, or to attempt to focus it distinctly, this gives rise to an impression of greater proximity of the object, and as the image on the retina is of course the same size as it would be were its distance more correctly estimated, it appears smaller. The *micropsia* thus occasioned is often very marked, and is met with both in cases where the paresis is the result of a direct, and where it is due to a reflex, interference with the functions of the branches of the third nerve which supply the ciliary muscle. The paresis may occur idiopathically, or be due to the action of a mydriatic. Conversely, a spasm of accommodation, from whatever cause, sometimes gives rise to *macropsia*,

as the consciousness of an abnormally feeble effort to accommodate the eye for a near object causes the object to appear more distant, and therefore bigger than it would be otherwise estimated. Macropsia has been observed after the use of such miotics as pilocarpine and eserine. Accommodative micropsia is most marked the nearer the object lies to the eye; accommodative macropsia, on the other hand, the farther it is removed from the eye.

But, besides metamorphopsia due to defects in accommodation, there are also similar misjudgments as to size, caused by abnormally impeded or facilitated movements of convergence of the optic axes, or by any optical conditions which permit of binocular fixation with the axes of vision directed so as to meet either nearer or farther off than the object looked at. Thus, prisms with the bases inwards in front of each eye appear to magnify, owing to the axes of vision meeting farther off than the objects looked at. Prisms with the bases outwards in front of each eye appear, on the other hand, to diminish, as under these circumstances the axes of vision cross in front of the objects fixed, which appear nearer and consequently smaller than would be the case without the prisms. Operations on the muscles of the eye are sometimes, if there has been previously binocular vision, followed by similar apparent alteration in the size of near objects. Metamorphopsia due to alterations in the percipient elements of the retina, brought about by choroidal exudation, is described in the chapter on diseases of the choroid.

Scotomata and clouded vision.—When a patient complains of seeing a spot or spots in front of the eye, we have first to inquire whether the appearance is stationary and constant, or is only seen when the eye is suddenly moved, or has an independent motion. Its behaviour in these respects gives a clue where to look for the cause. When stationary and always projected in the same direction with reference to that taken up by the eye, it will either be due to some circumscribed opacity of the cornea or lens, possibly also of the vitreous, or to some change in the retina. An interruption in the field of vision of this last nature is called a *positive* scotoma. When there is no consciousness of an interruption corresponding to the more or less blind area, the scotoma is said to be *negative*.

Where a lesion primarily involves the nerve fibres of the retina the resulting scotoma is unperceived or negative; where, on the other hand, lesions involving the retinal pigment and choroid cause the scotoma, there is more or less consciousness of its existence. The shape of a positive scotoma may often be

learnt by asking the patient to draw the outline of it on a piece of white paper. Positive scotomata are generally most marked in subdued light. Where the spot is not stationary it is generally due to the shadow cast by something in the vitreous.

Small spots, or *muscæ volitantes*, which cannot be detected with the ophthalmoscope, are very commonly complained of.

Clouded vision is often met with, and should direct attention to the choroid or to the possible existence of glaucoma. If intermittent in its character, there will often be reason to suspect glaucoma. Patients suffering from glaucoma often complain of seeing everything clouded even when they are found on examination to have full visual acuity.

Sensations of light and colour.—These may arise without there being any objective cause to account for them—that is, when no undulations of the ether, such as are capable of giving rise to luminous impressions, find their way to the retina. A purely subjective sensation of this kind may be the result of a mechanical or chemical stimulation of the nerve fibres of the retina or optic nerve, or of the centres of vision. The light so seen may appear coloured or uncoloured, according to the site and nature of the stimulation.

Direct pressure over a portion of the eye behind its equator produces in the dark a so-called *phosphene* or sensation of light, which is referred to the opposite side of the field of vision.

A common cause of coloured vision, owing to a change produced on the compound rays of white light as they enter the eye, is afforded by those states of the cornea which give rise to diffraction. In looking at the street lamps, for instance, through the glass of a carriage window, which is covered with the closely packed particles of moisture which arise from the condensation on it of the vapour within, one frequently notices the lights surrounded by coloured haloes. The same appearance may sometimes be observed without the intervention of the glass, and it is then usually pathological and due to a similar arrangement of intransparent particles in the cornea. This symptom of seeing haloes round lights is one of the commonest and most important indications of the early stage of glaucoma. Although a frequent symptom in glaucoma, such coloured haloes are by no means pathognomonic of that disease. They may be seen in all cases where the cornea assumes from any cause a diffuse cloudiness. Even the secretion which in some cases of conjunctivitis gathers across the cornea may give rise to them. When spontaneously complained of, and especially when there is no appearance in the cornea at the time of examination to

account for the halo, and when, too, it does not disappear on rubbing the eyes, its existence is strongly suggestive of glaucoma.

Test for the presence of binocular vision.—It is sometimes necessary to determine whether in any case binocular vision exists or not.

In this test, as made by Hering's method, the patient is caused to look with both eyes through a tube blackened inside, and across one end of which a string is stretched. If a small object, such as a bead or pea, be dropped immediately in front of or behind the thread, anyone with binocular vision can at once tell whether it has fallen nearer to his eyes or farther away from them than the thread. If binocular vision be absent, a few trials show that the relative distances of the falling object and thread cannot be appreciated.

Further Objective Examination.

The examination of the eye by oblique focal illumination is of the utmost importance, and should always be undertaken before making an ophthalmoscopic examination. It is done in the following way. The rays from the source of light used for ophthalmoscopic examinations are concentrated by means of a convex lens on the cornea. By slight movements of the lens the focus of light is made to fall on different parts of the cornea, and thus show up any imperfection. By its means any cicatrix, however faint, can be detected. By approaching the lens slightly to the eye the surface of the iris may be brilliantly illuminated, and more thoroughly examined than by mere inspection without the concentrated light. Oblique examination may be combined with some method of magnification. A rectangular portion of a large lens is very suitable for this purpose, as it admits of the structures being seen binocularly. A better idea is thus got of their relative depths. For the more minute examination of corneal affections it is customary to use a strong convex glass placed behind the ophthalmoscope, or a corneal microscope.

The action of the pupil, and the degree to which it contracts to light, may be tested by reflecting light on the eye by means of the ophthalmoscope mirror. In this way the light can be flashed on and off with a very slight movement of the hand holding the mirror. Its intensity can be altered by altering the distance of the mirror from the eye, or the strength of the source of illumination, which can readily be done if a gas jet be used. By keeping a constant degree of illumination on the eyes, and directing the patient to keep fixing the finger, as it is

approached gradually nearer and nearer to the face, the presence or absence of contraction of the pupils, which is normally associated with accommodation and the convergence of the visual axes, is tested. Even in cases where the patient examined is blind, the presence of an association between convergence and pupillary contraction may be tested by causing him to attempt to look at his own finger as he brings it nearer and nearer to his eyes. This will cause him to converge, and if

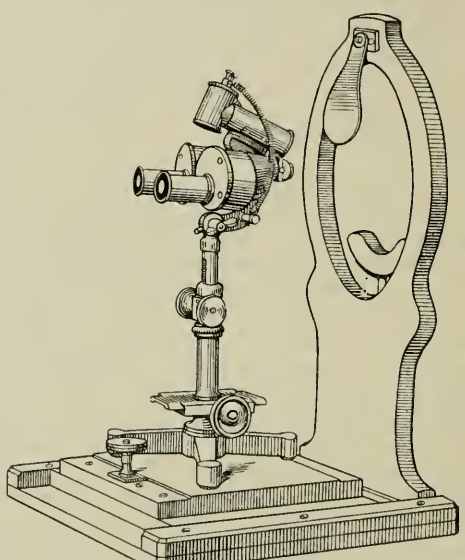


FIG. 10.—Binocular corneal microscope.—CZAPSKI.

there exists an associated pupillary contraction it will then be seen.

Examination with the mirror alone.—The central aperture of the mirror is held in front of the observer's eye, while the mirror is given such a direction that the light is reflected into the eye to be examined. As a rule, all that is seen by the observer, whose eye is placed behind the mirror, when light is reflected into the patient's eye with the mirror held at some distance from it, is a yellowish-red reflection from the back of the eye. If there is any detail seen in the red area of reflected light, it indicates that the eye examined is out of focus.

On the other hand, if the red reflex is either not seen at all when the light has been properly directed into the eye, or is found to be much duller than under normal conditions, or if it is interrupted here and there by more or less dark spots, the indication thus afforded is, that there is a diffuse or circumscribed opacity or opacities in one or more of the transparent media of the eye. If, on oblique examination, such opacity has not been found to exist in the cornea or lens, it may be inferred that it is in the vitreous. If the opacities have an independent movement, or are what is called "floating," they are at once recognised to be in the vitreous.

If the opacity causing the interruption in the red reflex is stationary, it is observed to have no movement independent of the eye, although there is an apparent movement as the eye is moved, which is greater or less according to the position of the opacity. If it lies behind the centre of curvature of the cornea (or more correctly, the image of that point which lies very near the point itself), it appears to move in the opposite direction from the eye. If it occupies a position in front of the centre of curvature of the cornea, it appears to move in the same direction as the eye, while the nearer it is to that point the less does it appear to change its position. Floating opacities are most readily made out by causing the patient to move his eyes rapidly in different directions, and then to keep them steady. The objects thus come into view in the illuminated area. Opacities in the lens may be limited, and can often only be seen if the pupil be well dilated with a mydriatic.

There are *two methods of obtaining an image of the fundus of the eye* with the ophthalmoscope, known as the *indirect* and *direct* methods of examination. The former is generally preferable, and in most cases all that is required; but when an examination by this method does not afford an explanation for an existing visual defect, or when it is desired to study more closely any pathological changes, the direct examination should be made in addition, as by it a much greater magnification is obtained. Special attention should be directed—(1) To the optic disc, and notice taken of its colour, the size and condition of the larger vessels which lie on it, and the state of the immediately surrounding parts; (2) to the periphery of the fundus, by causing the patient to look up and down, to either side, and, if necessary, slightly moving one's position so as to bring the most peripheral portions into view; and (3) to the macula lutea. The examination of the region of the macula lutea is often difficult. This is owing to the greater contraction of the pupil,

which takes place when the light is concentrated on the macula. In addition there is a disturbing effect produced by light reflected from the cornea. It is generally best not to ask the patient to look directly at the ophthalmoscope, but slightly to one side, and then by slowly moving one's head bring the macula into sight. In this way a view of it is often more easily obtained. Often, however, it is impossible to get a satisfactory view of the macula without dilating the pupil. When the appearance met with at other parts of the fundus is not sufficient to account for the symptoms, there should be no hesitation about using a mydriatic in order to be able to explore the macula properly.

The best mydriatic for the purpose is homatropine, as it does not produce such a prolonged paralysis of accommodation as atropine, though it has the disadvantage of acting considerably more slowly. It is also safer in the case of old people, in whom, if there is a tendency to glaucoma, an acute attack of that disease is more likely to be set up by atropine than by the weaker mydriatic. The effect of homatropine may be hastened by combining it with cocaine.

By the *indirect method of examination*, a magnified *inverted image* is obtained of the structures at the back of the eye. The observer, placing the back of the ophthalmoscope mirror in front of his eye in such a manner that he looks through the aperture in its centre, reflects the light from a lamp or gas jet, at the side of the patient's head, into the patient's eye, and from a distance of 12 to 18 in. With the other hand he holds a convex lens, of a strength of from 10 to 15 dioptres, in such a manner that its centre comes to lie in a line joining the patient's pupil with his own pupil, and at a distance from the patient's eye about equal to the focus of the lens. The same lens should always be used in making examinations, so as to give a uniform idea of the relative sizes of the different pictures obtained. To steady the lens in this position, it is customary to rest the little finger against the patient's forehead.

There is thus formed, between the convex lens and the observer, an inverted aërial image of some part of the back of the eye, which the observer can see if his eye is properly accommodated for the distance. By moving the head back and forwards, the position in which the image can be most distinctly seen is soon found. It will be farther away the greater is the distance of the observer's near point. Hypermetropes and presbyopes generally aid their accommodation by bringing a small convex lens behind the aperture of the ophthalmoscope.

By the *direct examination* a magnified *erect image* of the back of the eye is obtained. The observer, keeping his eye behind the aperture in the ophthalmoscope, reflects the light into the patient's eye from a distance of less than two inches, and receives the rays which pass back from the patient's eye into his own, and, focussing them on his retina, obtains an image of the structure from which they have been reflected. If the observer be emmetropic, and the patient emmetropic and unaccommodated, the image is obtained by the eye without any accommodation. If, on the other hand, the patient's eye be hypermetropic, the observer will have to exert a proportionate amount of accommodation, or place a convex lens sufficient to correct the hypermetropia behind the aperture in the ophthalmoscope in order to obtain a clear image of the fundus. If the patient or the observer be myopic, the latter will only obtain a proper definition of the image of the fundus by making the examination through a concave lens of sufficient strength placed behind the ophthalmoscope. It follows, too, that if the observer be myopic, and the patient hypermetropic, or *vice versâ*, no lens or accommodative effort will be required, if the amount of the defects neutralise each other; while, if they do not, the glass or accommodative change corresponding to the difference in the degree of ametropia is required to obtain a distinct image. This is more fully explained in the chapter on refraction, and cannot be properly understood unless the reader has some knowledge of the errors of refraction commonly met with.

Both with regard to illumination and magnification, the fundus of the eye is seen in a very different manner from any other part of the body. It is this which in great measure causes the difficulty of interpreting what one sees. It is customary to make use of the optic disc as a convenient measure with which to compare the size of any change seen, or to gauge the distance separating such changes from each other, or from any point (often conveniently the disc itself). Thus we might talk of some hæmorrhage or other spot in the retina being about half the diameter of the disc in size, and situated rather more than two diameters of the disc below it.

The relative depth of the different parts of the back of the eye, seen with the ophthalmoscope, can be estimated with tolerable accuracy by noting the number of the lens which the unaccommodated eye requires to obtain a clear definition, and allowing roughly 3 dioptres to 1 mm. By the indirect examination, differences in depth are rendered apparent by the parallactic displacement which takes place when the convex lens is given

a slight movement from side to side. The structures lying nearer to the eye then appear to glide over the deeper-lying parts as their image moves more rapidly in the same direction as the lens.

Normal Fundus Oculi as seen with the Ophthalmoscope.

A great variety of different ophthalmoscopic pictures are presented by altogether normal states of the back of the eye. Indeed, the art of ophthalmoscopy consists quite as much in recognising the physiological varieties met with, and in diagnosing the healthy fundus, as in understanding the nature of any pathological changes which may be present. It is usually comparatively easy to recognise the different diseases of the fundus oculi, often very difficult to feel sure that there are no pathological changes.

The *colour* which the fundus presents, and the amount of detail which can be made out, besides, of course, depending to some extent on the illumination and magnification, vary according to the density of pigmentation in the hexagonal cells of the retina. The red colour comes from the blood in the vessels of the choroid, but is modified by the pigment in the retinal hexagonal cells. The degree of pigmentation, again, bears a pretty close relation to the pigmentation elsewhere, so that a different appearance is usually presented by the eye of a very dark individual when compared with that of a light-haired one. In the two extremes, namely, the eye of the negro on the one hand, and of the albino on the other, the difference is very pronounced.

Apart from the actual depth of colour, it is usual to find a want of absolute uniformity of colour. The three regions where one most frequently notices differences in this respect, are the periphery, the area immediately surrounding the disc, and the macula lutea. In the periphery there is often more or less absence of pigment, causing a lighter colouring and greater visibility of the retro-retinal structures. Round the disc, on the other hand, a lighter colouring is often observable, owing to light reflected from the nerve fibre layer. In the region of the macula again, where the pigmentation is greater, there is always an increased depth of colour. A certain regular unevenness in the colour of the fundus throughout, giving rise to a stippled appearance, is more or less recognisable in different cases by the magnification obtained on direct examination.

Ophthalmoscopic appearances of the retina in health.—The retina, with the exception of its larger blood vessels, or more correctly, of the blood column in the vessels, is so transparent that in most parts it is practically invisible. In some eyes there is to be seen, and particularly in the neighbourhood of the macula, a kind of dull sheen of reflected light from the

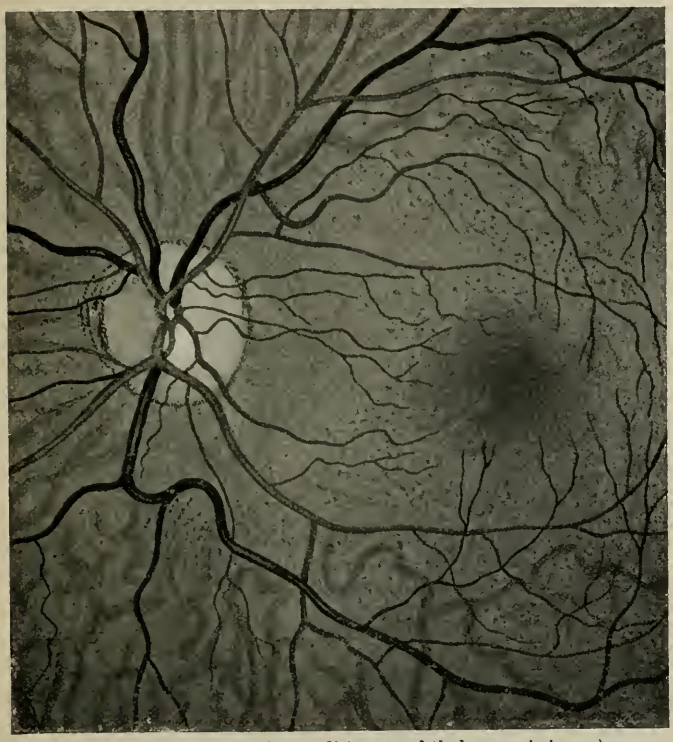


FIG. 11.—Normal fundus oculi (erect ophthalmoscopic image).

surface of the retina. In many eyes, too, there is a more or less marked striation visible, stretching from the disc for some distance in all directions, but mostly upwards and downwards. This striation is due to the presence of the nerve fibres which spread over the retina, and which in this position form a thicker layer than elsewhere.

The *macula lutea*, or yellow spot, is an area occupying the

centre of the retina in the direct line of vision, its centre or fovea centralis being that portion in which the visual acuity is greatest, and on which, therefore, the images of objects directly "fixed" fall. The macula is recognised by its occupying a position to the outer side of the disc, its centre being about two diameters of the disc from the disc margin, by its being relatively devoid of visible blood vessels, and by its darker colour. Sometimes it is seen to be circumscribed by a bright glittering band or "halo" of reflected light. At the centre of this halo, which is more or less distinctly elongated in a horizontal direction, lies the *fovea centralis*, a whitish,

FIG. 12.—Showing ophthalmoscopic appearance which may be presented by the normal macula lutea.

pinkish-white, or straw-coloured spot, often presenting at the same time a very marked glitter. The horizontal diameter of the macula is generally distinctly greater than the diameter of the disc; its vertical diameter, on the other hand, perhaps hardly as great as that of the disc. The deeper pigmentation is sometimes pretty sharply defined, but more often gradually fades off into the colour of the surrounding fundus. The yellow colour of the macula is never seen, owing, no doubt, to the preponderance of yellow rays in the light used for examination. The halo round the macula is mostly seen in children, and especially in deeply pigmented retinæ, and hypermetropic

eyes. The band of reflection producing it gradually fades off to both sides, sometimes sending indefinite streamers of reflection beyond, particularly to the outer side, or that farthest from the disc. It is, however, usually pretty sharply defined along the edge lying nearest the fovea, where it borders the more deeply pigmented area. Often a complete halo is not seen, but only a sickle-shaped portion of it. The concavity of the sickle then appears, on indirect examination, turned towards the middle line, though this may depend to some extent on the position given to the convex lens. The reason why the ring is not seen in the same way on direct examination is partly because of the different direction of the illuminating rays, and partly because the illumination is feebler. With a short-focus concave mirror there may be more or less indication of it on direct examination in cases where it is marked in the inverted image.

Often at other parts of the retina, too, in young individuals, reflections similar to, though less defined, than that round the macula, are seen as bands of light beside and between the larger vessels. The appearance of these reflections is not unlike watered silk. It is most marked in hypermetropes, and most distinct if the pupil is not dilated.

The *vessels of the retina*, which appear as darker lines on the reddish fundus, are seen to spring from the disc, or intra-ocular termination of the optic nerve. The arteries and veins are distinguished from each other in three ways, namely—(1) By the diameter of the blood column, that is to say, by their apparent relative sizes; (2) by their colour; and (3) by the manner in which they reflect light. The column of blood in the arteries is narrower than that in the corresponding and accompanying veins. The colour of the arterial blood is lighter, and, lastly, a very broad band of light reddish reflection is seen running down the centre of the artery. A streak of light is seen on the veins as well. It differs from that on the arteries in being whiter and much narrower. It cannot be traced so far along the course of the veins, and is often seen to be interrupted at places. The distinctness of the line is greater in both arteries and veins, the stronger the illumination of the fundus. The larger the pupil, therefore, the more distinct does the appearance become. An enlargement of the pupil produces, besides, an increase in the breadth of the line on the veins, but does not lead to any similar alteration of that on the arteries.

The light streak on the veins is caused by reflection from

the convex surface of the blood column, the refractive index of which differs from that of the transparent walls of the vessels. The broader line on the arteries is perhaps also caused by reflection from the blood corpuscles of the axial current.

The arteries, besides being narrower, are more tortuous than the veins. Not unfrequently they are even seen to twist round the veins at places. This twisting of the arteries round the veins, as well as the sharp turning of the veins, which often takes place as they emerge from the central depression on the disc, gives rise to an alternate, visible, partial emptying and refilling of small portions of the larger trunks on the disc, synchronously with the heart's action. This, which is called *venous pulsation*, is a very common physiological phenomenon, not to be confounded with visible pulsation in the arteries, which is probably always pathological.

The main trunks of the central artery and vein divide on the disc, or more frequently, some time before they come into view, into a superior and an inferior branch. The further division which takes place is always dichotomous, the narrowing becoming gradually more and more appreciable as the vessels pass to the periphery. The situation in which the main division of the vessels takes place on the disc, first into an upper and lower branch, and then each of these into a nasal and temporal portion, is subject to such great variety, that it is almost impossible to find two eyes with exactly the same arrangement in this respect. Even the number of vessels on the disc is not constant. The site at which the first division takes place may also produce some differences in the ophthalmoscopic appearance. Thus, when the artery or vein divides just on a level with the disc, having up to this point coursed in a direction parallel with the axis of the nerve, the appearances presented as one looks down, as it were, on the cross section of the main vessel, and therefore on a perpendicular column of blood, is that of a much darker spot at the point of division.

Sometimes vessels are found to the outer side of the disc, which are seen to spring into view at its margin, between it and the edge of the choroidal ring. These vessels, in the first part of their visible course, are usually directed towards the disc. After making a more or less extensive curve, they pass into the retina. They appear sometimes to be offshoots of the central vessels which have passed out of the nerve before reaching the disc. They are more frequently, however, branches of the short posterior ciliary arteries, and have received the name of *cilio-retinal vessels.*

Ophthalmoscopic appearances of the optic nerve in health.—The optic disc, or the end or cross section, as it were, of the

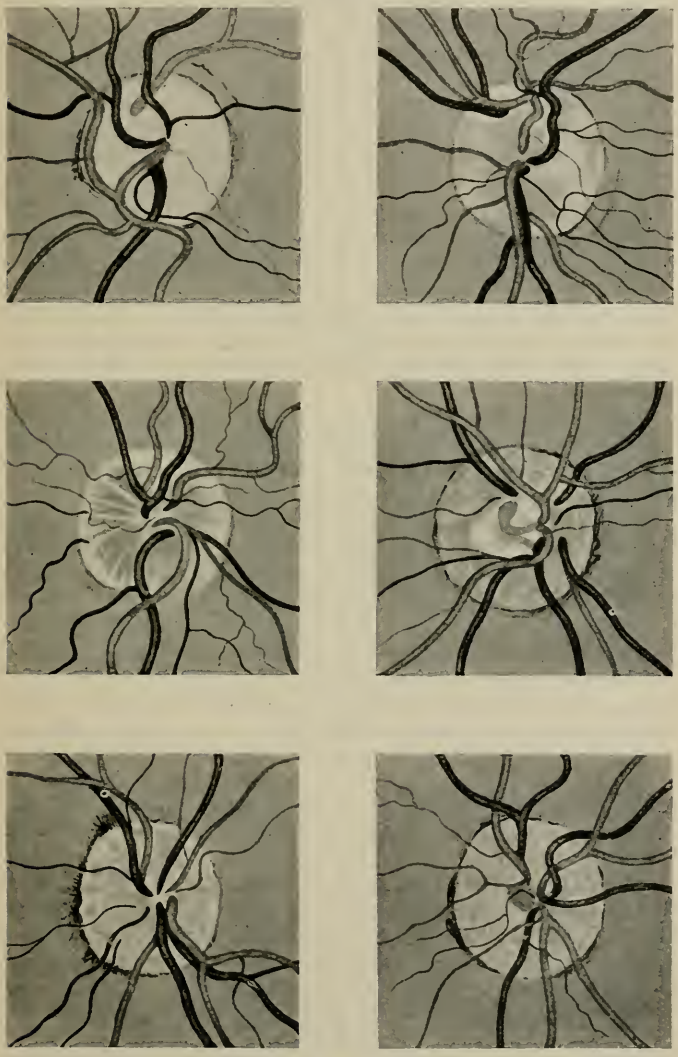


FIG. 13.—Normal discs, showing different arrangement of vessels, etc.

optic nerve, that portion which is alone visible with the ophthalmoscope, receives its name from its circular *shape*. Its real diameter varies in different individuals from 1·5 to 1·75 mm. There is often, too, a difference according to the direction in which the measurement is made. It is, in fact, rarely a very perfect circle, though, in the majority of cases, it is very approximately circular. Considerable differences are met with: thus it may be very decidedly elongated in one direction, most frequently obliquely, but with the long axis nearer the vertical than the horizontal. It is sometimes flattened more or less at one or more parts. It is important that the natural oval shape of the normal disc, in some cases, should not be confounded with the oval form seen, owing to purely optical conditions, where there is astigmatism. In order to convince ourselves that the oval form is that really presented by the intra-ocular end of the nerve, we have only to withdraw or approach the convex lens, and observe that no alteration of shape takes place.

The disc is far from having a uniform colour, and the *colour* is one which is not very easily described. It is subject, besides, to considerable variation. This should be remembered, and great care exercised not to infer too readily that an apparently excessive degree, either of pallor or redness, is pathological. At first sight it is markedly pale or white as compared with the rest of the fundus. What gives the white appearance is the reflection of light from the lamina cribrosa, the altered sclerotic coat through which the nerve passes. But a closer inspection shows that the disc is not by any means colourless. It is of a rosy-pink colour, which at some parts appears as if mixed with grey, at others with blue, and through which, one, as it were, sees the white light shining. The colour varies according to the degree of illumination, and is less uniform in a feeble or moderate illumination than in a very strong one. The differences in colour, too, are most clearly seen on direct ophthalmoscopic examination. The most markedly pinkish portion is almost always a greater or less crescentic bit of the inner or nasal half of the disc, that portion which is farthest away from the macula. This part is often so decidedly coloured that it presents but a slight difference from the surrounding fundus when the illumination is not great. There is always, however, an appreciable difference in hue.

The pinkish colour of the disc is due to the reflection of light from the blood in the vessels which supply the intra-ocular end of the nerve; and it is owing to the layer of nerve tissue

being thicker, and consequently occupied by a greater number of blood vessels to the inner side than elsewhere, that the colour there is deeper. Less light penetrates through to, and is reflected from, the underlying lamina cribrosa than in other parts, where there is a thinner layer of nerve fibres. The least coloured, and often decidedly, even intensely, white portion of the disc, is its centre. At this spot, owing to the separation of the nerve fibres in all directions, there is a little conical, funnel-shaped depression formed, at the bottom of which there is nothing but the lamina cribrosa, the light reflected from which does not suffer any alteration before it meets the eye. The result is, therefore, that one sees a white circular spot in this situation, which sometimes, on direct examination, exhibits some indication of the structure of the lamina cribrosa. Often the white area is not circular, but, while very markedly white, and contrasting strongly with the bordering coloured portion to the inner side of the disc, merges more slowly into a deeper colour in other directions.

Not unfrequently starting from this point, a sector-shaped area of the outer or temporal portion of the nerve is very devoid of any pinkish colour, and presents instead a mottled bluish-white aspect. This mottled appearance is due to reflection of light from the lamina cribrosa, and the nerve bundles which pass through that fibrous meshwork. The strong dull white is caused by reflection direct from the fibrous tissue; the steel-coloured, bluish-white, more diaphanous appearance, on the other hand, is the result of repeated reflections from the pits or channels in the connective tissue through which the transparent nerve fibres pass. This appearance of the outer half of the disc, which is sometimes seen, appears to depend more on the absence of blood vessels, than on the absence of nerve fibres in that region, although they undoubtedly form there a shallower layer than in other parts.

Occasionally masses of pigment, which rarely attain any size, are seen in the disc. These pigment spots are mostly formed near the margins.

The *margins of the disc* are always sharply defined, though sometimes this definition is less marked above and below than elsewhere. The disc is usually seen to be surrounded by a white or slightly yellowish-white ring. This is what is called the "scleral ring." This ring varies considerably in breadth in different cases, but is most frequently very narrow, only just discernible on careful examination by the direct method. The scleral ring is formed, as its name implies, by a surrounding

portion of the sclera, the white colour being due to the strong reflection from that coat. The opening in the choroid is always larger than that in the sclera, and hence it is possible to see this portion of the sclera; although, owing to the overhanging of the expanded intra-ocular end of the nerve, as well as to the frequent heaping up of pigment at the margin of the opening in the choroid, the view of the sclera in this situation is often very much masked. The portion of the ring to the outer side of the disc is commonly the most evident. It is in this direction too, mostly, that it is usual to find some pigment accumulated at the margin of the choroidal opening or "choroidal ring."

Physiological excavation of the disc.—One of the most important and frequent variations from the typical condition of the disc, is that to which the name of physiological "cupping," or "excavation," of the disc is given. This variety in the conformation of the intra-ocular end of the nerve is met with in very different degrees and in different forms. Altogether, some degree of cupping is about as frequent as the absence of any cupping at all. Although they vary thus greatly, all physiological excavations have the following characteristics in common: they never occupy the whole area of the disc, and they never extend deeper than to the lamina cribrosa. Further, the condition is nearly always met with in both eyes, though not always to the same extent. These points should be remembered in distinguishing a physiological from a pathological excavation.

The physiological excavation is merely a broadening out of the normal depression met with at the centre of the nerve. The sides, or some part of the sides, of this widened depression are sometimes steep, even occasionally overhanging, at other times sloping. The result of a steep cupping is, that on following the vessels along the disc, towards its centre, they are seen to suddenly come to an end, owing to the straight dip which they make down the side of the excavation. They reappear at the bottom of the excavation, where they are not in focus at the same time with those on the surface of the disc and retina. At the same time, the deeper lying portions often look as if they were not continuous with the others, owing to the change in direction which has taken place in the portions hidden from view. The white area of excavation contrasts very markedly with the pink surrounding portion of the disc. The vessels in this white area, which, when those on the retinal surface are in focus, look paler, as it were washed out, and on which the clear streak of reflection is absent, assume a more normal appearance on accurate focussing. At the same time, the indefinite white or

bluish-white area on which they lie also comes into focus, and shows more or less of the reticulated steel grey, or blue and white meshwork of the structure of the lamina cribrosa. The mottled bluish marking is very different in different cases, as it is only seen when the nerve fibres have lost their myeline sheath at some distance back. In the more funnel-shaped excavations, the vessels may be traced down the side of the cup.

In all cuppings, but most markedly in the sharp ones, the vessels at their points of flexure appear darker, owing to one's looking down upon a deeper column of blood. However sharply

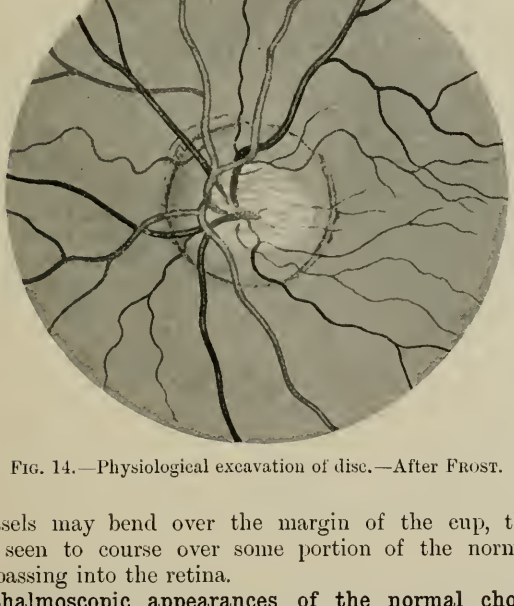


Fig. 14.—Physiological excavation of disc.—After Frost.

the vessels may bend over the margin of the cup, they are always seen to course over some portion of the normal disc before passing into the retina.

Ophthalmoscopic appearances of the normal choroid.—When the pigment in the hexagonal cells of the retina is abundant, all that can be seen of the choroid is the red or orange-red colour, reflected from the blood, in its numerous blood vessels. The intensity of this colour, too, is, as has been said, dependent upon the density of the pigment, so that the red is much less pronounced in very dark individuals. Where the pigment in the hexagonal cells is scanty, on the other hand, the

vessels of the choroid come into view. As the larger trunks of the choroidal veins lie towards the equator of the eye, the structure of the choroid is often more visible at the periphery than at the centre, where too the pigment is usually more dense. On this account, it is comparatively rarely, under normal conditions, that much of the choroid is seen at the centre of the fundus.

The *choroidal veins*, when visible, present themselves as a dense network of broad and narrow stripes, of a pale red, orange, or yellow colour, separated by lighter or darker interspaces, according to the amount of pigment contained in the stroma of the choroid. If there is a great absence of pigment, both in the hexagonal cells and in the choroidal stroma, the veins of the choroid may be visible in their finest ramifications, or, at all events, as far as the magnification of the ophthalmoscopic image admits of. The interspaces then appear non-pigmented, and reflect a yellow or reddish-yellow light. They vary in size, and their shape is mostly that of an irregular rectangle. The interspaces are more elongated towards the periphery than at the centre, in the region of the macula.

Sometimes the choroid itself is well supplied with pigment, although that of the retina is sparse. The interspaces are then darkly pigmented, and only the larger vessels are visible.

A zone at the extreme periphery of the choroid, which lies anterior to the equator of the eye, cannot be seen with the ophthalmoscope.

CHAPTER III.

DISEASES OF THE EYELIDS.

The obvious function of the eyelids is to protect the eyes from external injury, and thus preserve the transparency of the cornea. The lids, with their lashes or cilia, prevent substances of any size coming in contact with the cornea, and furnish an oily secretion which lubricates the surface, and thus obviates any intransparency of the cornea which might arise from the drying or hardening of the superficial layers of its epithelium. The tears, too, aid in this, and at the same time tend to wash away any minute substances which may lodge within the eye.

The lid aperture varies considerably in length in different individuals, and always appears larger when the eyes are prominent, and smaller when they are sunken. The points where the upper and lower lids meet at an angle are called the outer and inner *canthi*. Rather less than a quarter of an inch from the inner canthus, and just at a point where the lid margins begin to narrow, are situated, both above and below, the slight papilliform elevations in which the little channels or *canaliculi* leading to the tear sac end. The small punctiform apertures leading into the canaliculi are the so-called *puncta lachrymalia*. The eyelashes spring from the outer portion or edge of the margin of the lid; their roots, which are from 2 to 3 mm. long, being embedded in the dense fibrous tissue.

The substance of that portion of the lid which covers, or is directly applied to the eye, is composed of four layers, which, proceeding from within outwards, are (1) the conjunctiva; (2) the tarsus; (3) a layer of muscular fibres; and (4) the skin. In this situation, the conjunctiva is very closely adherent to the underlying dense fibrous tissue or *tarsus*. Beyond this, it is thrown into folds, and only supported behind by a much looser connective tissue. The tarsus of

the lower lid is an insignificant, narrow, and thin structure; in the upper lid it is thicker and much deeper, and to its free margin is attached the tendon of the levator palpebræ superioris. An oily secretion is formed in the tarsal or *Meibomian glands*, and passes out of numerous ducts which open along the margin of the lid. Immediately below the skin of the lid, which is extremely lax and movable in all directions, is the *orbicular muscle*, the function of which is to close the eyes. This muscle, which is supplied by the seventh nerve, is a large flat structure, composed entirely of voluntary muscular fibres, and extending over the margins of the orbit, above and below. It has tendinous attachments to the inner and outer palpebral ligaments.

The upper lid is raised by the levator palpebræ superioris, which is innervated by the third nerve. To some extent also that muscle receives assistance from a bundle of non-striped fibres, which lie under the conjunctiva, and are attached to the free edge of the tarsus. These fibres are generally called *Müller's muscle*; they also exist in the lower lid, and are innervated by sympathetic nerve fibres.

Blepharitis.—This is one of the most common affections. It often occurs in children who are either strumous or ill-nourished, and dirty and ill-cared for. It is then frequently associated with phlyctenular conjunctivitis and keratitis (*q.v.*). The inflammation begins with hyperæmia and increase of the secretions. When this is not attended to, the secretion becomes fibrinous and glutinous, and seals the eyelashes together, forming crusts or scales, under which a process of ulceration, leading to destruction of their follicles, takes place. The affection is met with in very different degrees of severity, from what is merely a tendency to slight scaliness of the lid margin, to the formation of marked pustules, the irritation of which causes considerable œdema and inflammatory swelling of the lid.

A sufficiently useful etiological classification of cases of blepharitis would include three groups, which, however, can hardly be said to be always absolutely distinct. The so-called strumous cases, already referred to, form one of the groups. They are often associated at times with attacks of phlyctenular inflammation of the conjunctiva and cornea. Another group would include the cases which are more or less evidently connected with a chronic catarrhal condition of the tear sac. The last group would comprise those of herpetic or eczematous blepharitis, as the third variety has sometimes been called. In

these there is an absence of the strumous element, and usually, at the same time, of any evidence of auto-infection from local sources. They mostly occur in adults, often along with more general eczema of the skin of the lids.

The worst cases of blepharitis belong to the two first groups. The inflammation in them often goes the length of ulceration, and this ulceration leads to greater or less destruction of the eyelashes. In old-standing cases it is common, indeed, to find a complete or practically complete absence of eyelashes. This gives rise to an ugly, red, blear-eyed appearance, which is very characteristic. Short of this there may be an alteration in the colour and character of the lashes, many of those remaining being misdirected, and thus leading sometimes by their inversion to irritation or ulceration of the cornea. The ulcers of the lid margin, as they extend in depth, partially or completely destroy the hair follicles, and then cause these changes in, or the loss of, the eyelashes.

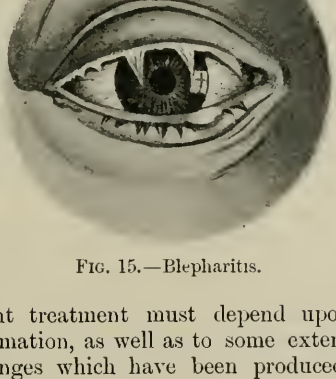


Fig. 15.—Blepharitis.

In the *treatment* of all cases of blepharitis, the first step should be to remove the crusts or scabs which have formed, and to epilate, with the cilia forceps, all the eyelashes which present a distinctly abnormal appearance in their colour, their thickness, or the direction of their growth. The subsequent treatment must depend upon the etiology of the local inflammation, as well as to some extent upon the severity of the changes which have been produced. Sometimes, when the ulcers of the lid margin have become to a great extent confluent, a really satisfactory preparation for local applications can only be got by first cutting all the lashes off with a pair of scissors. This is comparatively seldom necessary, however. Before attempting to remove the scabs, it is best, in the more pronouncedly impetiginous cases, to apply a starch poultice, in order to soften them. They can afterwards be carefully and thoroughly picked off with a piece of quill, without causing much pain. Until this is done, any epilation that may be required should not be begun. Besides saving trouble, owing to many of the diseased lashes coming

away with the scabs, it is then easier to see from the little ulcer pits which lashes it is advisable to pull out. When from the raw surface thus exposed there is found to be an exudation in which there is an evident admixture of pus, which is only rarely the case, and only in the strumous variety of blepharitis, it is well to paint the lid margin over once with a 5 per cent. solution of nitrate of silver, dabbing the solution well in to the ulcers with the camel's-hair brush. This should be followed up by the use, three or four times daily and for a quarter of an hour or so at a time, of compresses soaked in a $\frac{1}{2}$ per cent. solution of the neutral subacetate of lead. After these have been used for a few days, recourse may be had to the yellow oxide ointment.

℞ Hydrargyri oxidi flavi	10 grs.
Vaselini albi	$\frac{1}{2}$ oz.

This should be well smeared along the lid margin morning and night.

Occasionally from neglect, or owing to some particularly marked delicacy on the part of the patient, often from both combined, and always in young children, the lid margin inflammation is not only ulcerative, but is associated with a great deal of deep infiltration, so that the tissues of the lid, and especially the tarsus, are much swollen and thickened. In such cases the ordinary treatment is of no use. As the eyelash follicles are then irretrievably destroyed, and there is consequently no good attempting to save them, the best treatment is to freely scrape away the ulcerated tissues with a small Volkmann spoon, and then undermine the skin and transplant it over the comparatively healthy raw surface which is left.

The general treatment in the case of the strumous variety of blepharitis should be on the same lines as that referred to in connection with phlyctenular keratitis (*q.v.*). Dark glasses should be worn outside in summer, and also in winter when there is snow on the ground. The skin should be kept clean by frequent baths, and cod-liver oil or syrup of the iodide of iron given internally.

In a number of cases of less severe blepharitis, which do not rapidly improve by the use of the yellow oxide ointment, efficiently applied after the scabs and crusts and diseased eyelashes have been removed, it becomes advisable to slit up the canaliculi. This should always be done when any regurgitation of mucus or muco-pus can be got by pressure over the tear sac. In any case, it should always be done whenever a blepharitis exists

for a long time on one side alone. In such a case it often happens that the blepharitis rapidly disappears without any further treatment, although it may previously have resisted other therapeutic measures. There is not, however, the same justification for early interference of this kind in bilateral cases. In them it should not be undertaken, unless there should either be definite evidence of a catarrhal state of the mucous membrane of the tear passages, or a decided rebelliousness to the treatment recommended above.

The eczematous variety of blepharitis, besides being practically only met with in adults, never assumes the impetiginous type which characterises so many cases in strumous children. Hyperæmia of the lid border, with a scaly crusting, and some-

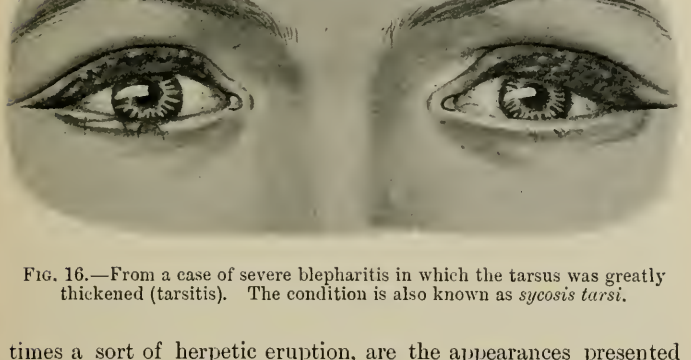


Fig. 16.—From a case of severe blepharitis in which the tarsus was greatly thickened (tarsitis). The condition is also known as *sycosis tarsi*.

times a sort of herpetic eruption, are the appearances presented by this form. In the milder degrees the lid margin has a look almost as if it had been dusted over with flour, although the numerous small scales are hardly as white.

The treatment should consist in bathing with warm water, the lid margins being well rubbed with a wet pledget of cotton-wool, and the following ointment applied night and morning after the bathing :—

R Zinci oxidi	20 grs.
Ichthyol	1 ,,
Vaselini albi	½ oz.

Attention should be paid to the conditions under which the eyes are used, and sources of irritation, such as dust or smoke

or impure air, removed as far as possible. Dark glasses are also sometimes useful. Further, it is always advisable to correct any existing error of refraction, especially for near work. In troublesome cases it is well to recommend an anti-gouty diet. It is specially important to knock off alcohol, particularly if, as is often the case, it happens to be freely indulged in.

Hordeolum or stye.—The stye is essentially a furuncle of the lid margin. The inflammation arises in the sebaceous glands surrounding an eyelash, no doubt as the result of some form of infection. As a rule there is little difficulty in recognising a stye. Sometimes, when the inflammation surrounding the eyelash bulb has caused very considerable œdema of the lid and chemosis, and particularly if the stye is situated near the outer canthus, the cause of the œdema may not be so apparent. The site of the pain on pressure is then of importance in enabling one to arrive at a diagnosis. On running the finger along the lid margin, or on grasping the lid border between the fingers, a sharp pain will be felt when the disturbance is caused by the presence of a stye.

The acute localised inflammation comes to a point somewhere on the margin of the lid, and thus differs from a suppurating tarsal cyst, which invariably points on the conjunctival or skin surface.

The treatment in the case of styes has to be both palliative and prophylactic. At first warm compresses of lead lotion (a 1 per cent. solution of the neutral subacetate), or of alum lotion (4 grs. to the ounce of water), may be used. When the stye has begun to point, it may be incised. In doing so, a small opening is made in the long direction of the lid margin. Afterwards the thick matter may be squeezed out by pressure between the forefinger and thumb, and a poultice applied. When crops of styes appear simultaneously, or several come on one after another, to which in most cases there is a more or less marked tendency, it is important to take the patient's general health into consideration. Usually he is found to be run down, or to be suffering from some gastric derangement. A short course of a natural aperient water should be prescribed, and followed by a tonic containing iron and quinine. Exercise in the open air is also indicated. This treatment is generally efficacious; but special indications may be present in some cases, as where the diathesis is either markedly strumous or markedly arthritic or gouty. In all cases it is well to use the following ointment as soon as the acute inflammation has subsided :—

℞ Unguenti hydrargyri nitratis (B.P.) . . . ½ drm.
Vaselini albi . . . . . ½ oz.

This should be smeared along the edges of the lids of both eyes night and morning. It may be said to have almost a specific action in preventing the recurrence of this troublesome and painful form of inflammation.

Molluscum contagiosum is another affection frequently met with along the margin of the lids. It occurs on the skin of the lids as well, and there the cysts may attain a greater size. The circular shape of the swellings, and the little depression in the centre, give to them quite a characteristic appearance. They are often found in several members of the same family. The affection is common in children, and occasionally goes on to suppuration.

The *treatment* consists in snipping off the smaller growths with a pair of scissors, and in transfixing the larger ones, and pressing out the sebaceous matter which they contain; the cyst wall may be drawn out, too, with a pair of fine forceps.

Warts, papillomata, and **translucent cysts** also occur along the lid margin. They should be removed with as little mutilation of the normal tissues as possible, so as to avoid any misdirection of the eyelashes, which is liable to occur from cicatricial contraction. A condition which is often complained of, and generally more on account of its unsightliness than for any great discomfort to which it gives rise, is a sort of blind pimple on the lid margin. Usually there is only one, though occasionally there may be several elevations of this kind at different parts of the margin. The pimple appears as a uniformly red conical elevation. Its base occupies mostly the portion of the flattened lid margin which is in the neighbourhood of its free outer edge. Often there are epithelial squames at other parts, indicating a slight degree of blepharitis, but this association may be quite absent. These pimples occur mostly in adults, and often in cases which present more or less evident arthritic symptoms. They do not cause much discomfort, and are usually complained of more on account of the disfigurement.

This depends partly upon the size, of course, but mainly on the degree of congestion which the little prominences present. The natural duration of the pimples is variable. They may only last a few weeks, but often they remain in much the same state for many months. Usually, however, in the chronic cases, the redness, which at first is marked, tones down to a great extent, so that the adventitious tissue assumes nearly, if not quite, the colour of the rest of the lid margin, and consequently becomes much less apparent. On everting the lid there is always found to be a little circumscribed area of hyperæmia of

the conjunctiva, roughly triangular in shape, with its base directed to the portion of the lid margin on which the pimple has formed, and in chronic cases a yellowish streak coursing down the middle of the hyperæmic patch. This is simply a Meibomian duct blocked with secretion which has become more or less calcareous. Even in recent cases it is usual to find a degree of transparence in the middle of the congested conjunctival area, behind which some whitish secretion in the duct shows itself.

The *treatment* consists in emptying out this retained secretion. This can be done at first by simply pressing the affected portion of the lid between the two thumb nails, which causes the natural exit at the lid margin to burst open and give escape to a sebaceous-looking secretion. In cases which have lasted for some time it is necessary to incise from the conjunctival surface, making the cut along the yellow streak referred to, and up to the base of the pimple, and then to press out the contents. The pimple itself in either case then quickly disappears. In recent cases it almost immediately loses its hyperæmia, and this of itself is always a cause of satisfaction to a patient who has been mainly annoyed by the unsightliness which it has produced. Not unfrequently there are found to be other little patches in the lid of the same nature, though rarely as large, but which are not complicated by the protrusion at the margin. These should be treated in the same way, and preferably at the same sitting. An astringent lotion may be used for some time afterwards.

Herpes frontalis.—This is a rather uncommon disease. The eruption, which is limited to the one side, generally occurs on the forehead and lids, and sometimes the side of the nose as well. When the branch from the fifth, which supplies the side of the nose, is affected, the cornea may become ulcerated and the iris inflamed. The eruption is generally preceded by intense neuralgia, which rarely lasts more than a day or two, though occasionally much longer. The blebs, which then appear, are at first clear. After two or three days their contents become muddy; ulceration then takes place, and they eventually leave scars. The scabs fall off in about two weeks from the appearance of the eruption, but the neuralgia may continue, although the skin itself is more or less anæsthetic. I have seen the eruption confined entirely to the upper lid, and in one case it occurred first on one side and then on the other, after several years' interval. I have also seen recurrence on the same side. Herpes frontalis is considerably more common in men, especially old

men, than in women, and is said to occur twice as often on the left side as on the right. The disease has been shown to be produced by a lesion of the Gasserian ganglion, but it is doubtful whether this is always the cause.

In the *treatment* an attempt should be made, where possible, to obviate or mitigate the suppuration of the vesicles by keeping the patient in a room illuminated by non-actinic light, as in the Finsen treatment for smallpox. Locally, when the neuralgia is severe, subcutaneous injections of morphia are useful. After recovery, the patient should, if possible, be sent for change of air, and the diet should be nourishing.

Xanthelasma.—This is the name given to a yellow patch of irregular outline which occurs in the skin of the lids. It is almost always met with in both upper lids at the same time, though the patch may be much larger and more prominent in the one than in the other. It consists of fibrous tissue containing some altered blood pigment.

The patches may be removed without difficulty if the patient wishes it, as is sometimes the case, on account of their somewhat unsightly appearance.

Eczema may extend to the lids from other parts of the face, or begin originally in the lids as an extension from a conjunctivitis or a blepharitis, which, as we have seen, is in reality nothing else than an eczema of the lid margin. Some people are particularly subject to this; thus I have several times seen an acute eczema of the lids set up by compresses of corrosive sublimate solution even in the dilute form (1 in 5000), in which it is found useful as an antiseptic preparation in various affections of the cornea, and as a dressing after operations on the eye. It is occasionally also set up by atropine, when used as an anodyne and mydriatic, in different affections of the eye. Conjunctivitis in children is frequently associated with eczema. It is then often due to the practice of poulticing the eyes, which is a common popular remedy, leading to much increase in the severity of what would be otherwise very slight ailments. Sometimes, however, the eczema is produced by the same micro-organism which causes the conjunctivitis.

In adults, zinc ointment with or without the addition of a little ichthyol, or boracic acid ointment, are as good local applications as any; in children, perhaps nothing is better than Pagenstecher's ointment, the part being well washed first with black soap and water.

Milium, or small, circular, white tumours, rarely more than a pin's head in size, are often found in considerable numbers in

the skin of the lid and cheek. The epidermis covering them is very thin, so that they are of a pearly white colour.

They are removed by incision, and by squeezing out the compressed and altered epidermis which they contain.

Chalazion, or tarsal cyst.—A very common cause of circumscribed swelling in the lid is a retention cyst in the Meibomian glands of the tarsus. The retention gives rise to an inflammatory new growth, the size of which may vary greatly. After having attained to a certain stage in its development, the tarsal cyst tends to become inflamed. The inflammation may be associated with considerable œdema of the whole lid. It always then causes more or less pain, though an inflamed tarsal cyst is not so painful a condition as a stye. The inflamed cyst not unfre-

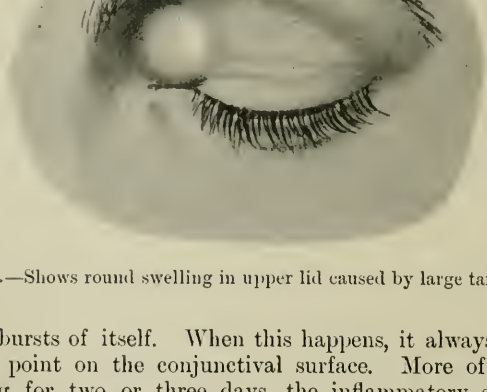


Fig. 17.—Shows round swelling in upper lid caused by large tarsal cyst.

quently bursts of itself. When this happens, it always does so at some point on the conjunctival surface. More often, after persisting for two or three days, the inflammatory symptoms subside, and the swelling diminishes in size, leaving only the hard lump which characterises the chronic cyst in this situation. A tarsal cyst may occasionally undergo spontaneous absorption, either with or without having become inflamed.

The cyst may occur in any part of the thickness of the tarsus, and may, as it increases in size, extend either towards the conjunctival or skin surface of the tarsus. It is easily felt as a firm mass, over which the skin is usually freely movable. Most frequently it is not long before the adjacent conjunctiva is found to be altered in its appearance. A darker, somewhat translucent, coloration, and sometimes a more or less evident

localised prominence of the conjunctiva, then marks the position of the cyst.

The *treatment* which should be adopted is to incise the cyst, shell out its contents, and afterwards break down its capsule or wall. Generally it is best opened into from the conjunctival surface. The incision in the conjunctiva should be made in a radial direction, at right angles to the lid margin. It should freely open into the cyst through the discoloured portion of the conjunctiva. By then pressing the lid between the thumbs of either hand, the cyst contents are squeezed out. With a small metal scoop any remaining débris may be shelled out, and at the same time by a little rough scraping with the same instrument the sac wall be sufficiently destroyed. Too much or too rough

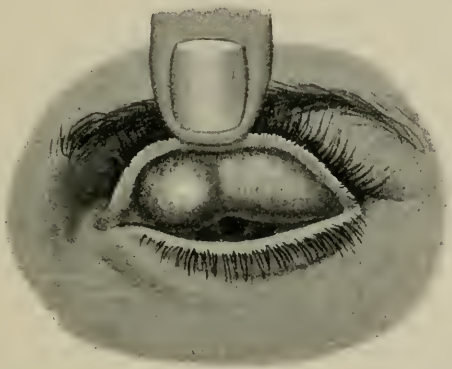


Fig. 18.—Shows the appearance on the conjunctival surface of the same tarsal cyst.

scraping is apt to cause an unnecessary amount of ecchymosis. In the less frequent cases in which the cyst mainly extends towards the outer surface of the tarsus, and thus comes nearer to the skin of the lid, the incision may be made through the skin. It should then be made parallel to the lid border, and followed by the same manipulations as just described. An incision in this situation and direction leaves practically no noticeable scar, owing to the natural wrinkling of the lid skin.

There is no certain means of preventing the subsequent recurrence of the tarsal cysts. If the little operation described has been properly carried out, there is never any recurrence at the same spot, but in many cases there is a decided tendency for

other portions of the tarsus of both upper and lower lids to become the sites of other cysts. Often a considerable time—it may be years—elapses between the formation of one cyst or one crop of cysts. Occasionally, if the condition is observed when just beginning, the cyst may be dispersed by pressing the lid firmly between the forefinger and thumb. This treatment is generally only applicable where, while treating one or more fully-developed cysts in the ordinary manner by incision, others are found to be present which are just in process of formation. Otherwise, it is seldom that one has an opportunity of putting it in practice. No doubt the cleansing, too, of the conjunctival sac once or twice daily with boracic acid solution is a useful precaution to take. For instance, the lotion may be used in the morning, after the secretions have to some extent become retained during sleep, and again at any time, as on a dusty day, that there has been some more than ordinary cause of irritation. The occasional use of a mild astringent, such as the tannic acid solution, referred to in the treatment of conjunctival hyperæmia, may be also recommended.

Chalky infarcts in the Meibomian glands are met with mostly in elderly people who have suffered from chronic hyperæmia of the conjunctiva. When these little yellow concretions project beyond the surface of the conjunctiva they are apt to set up irritation by scraping against the cornea, and should then be removed.

Trichiasis, sometimes occurring as a congenital abnormality, but more frequently as the result of blepharitis, is a misdirection of the eyelashes, which gives rise to more or less irritation by their rubbing on the cornea. The condition is called trichiasis.

Treatment.—When the trichiasis is only partial, a temporary improvement is obtained by epilation. In some cases where a few eyelashes only have been left altogether, the patient may procure for himself a pair of forceps, and have the eyelashes removed whenever they cause irritation. A radical cure can, however, only be obtained by some operation. The simplest, where a few cilia only are misdirected, is destruction by the actual cautery, or preferably by electrolysis, of the follicles from which they grow. In more general trichiasis some operation for the transplantation of the follicles (see under entropion) has to be adopted.

Entropion.—When the lashes rub against the cornea, owing to an incurving of the lid margin, the condition receives the name of entropion. Of this there are two principal varieties, *spasmodic* or *muscular* entropion and *cicatricial* entropion. The

most common source of the first variety, which is mostly met with in the lower lid, is some irritation of the eye which gives rise to spasmodic contraction of the palpebral portion of the orbicularis. Under such conditions the inversion of the lid is favoured by a lax condition of the skin, and a narrowness of the palpebral aperture. It is very often met with in old people after operations.

The *treatment* of spasmodic entropion must consist both in mechanically counteracting the inversion of the lid and in removing the irritation which leads to the frequent forcible orbicularis contractions. In a number of cases, and particularly in those in which there is only a temporary source of irritation, as after a cataract or other operation, all that is necessary is to

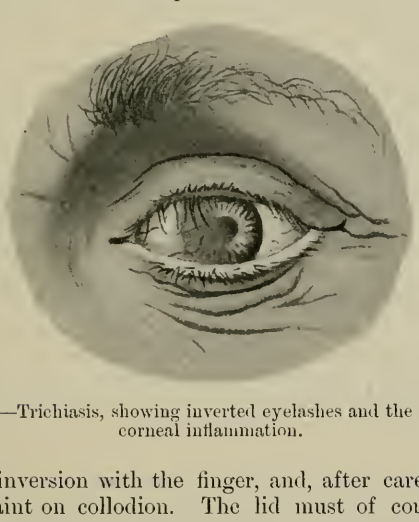


Fig. 19.—Trichiasis, showing inverted eyelashes and the resulting corneal inflammation.

reduce the inversion with the finger, and, after carefully drying the skin, paint on collodion. The lid must of course be held down, and somewhat everted, until a sufficiently thick layer of the collodion has had time to dry, and thus keep up the mechanical effect. This treatment may be tried, before resorting to anything more radical, in all cases which have not lasted very long, and in which the lid has not, as it were, got a set in the inverted position. The collodion has frequently to be reapplied—at least once daily, this depending upon the extent to which the layer becomes softened by overflowing tears. At the same time the local irritation should be allayed by frequently bathing the eye with warm boracic acid lotion, and afterwards dropping in a solution of cocaine.

Dark glasses should also be worn, and reading or writing disallowed for some days.

Although the collodion treatment is often successful in earlier cases, there is in many a tendency to relapse. In many, again, the treatment fails to give even temporary relief. Recourse must then be had either to a thread operation, or to excision of a piece of the redundant lid skin. The most commonly employed thread operation is known as Gaillard's. This consists simply in passing three or more loops of thread beneath the skin of the lid, and knotting them on pieces of drainage tubing at a greater or less distance down the cheek. One end of a thread, which must be aseptic, is entered immediately below the lid margin, and passed downwards for an inch or so below the skin towards the cheek before being brought out. The other end is entered in the same way, close to the first. This forms a loop. The three or four loops thus placed close to the lid margin are then knotted. They may be allowed to remain as long as they do not produce too much irritation, and the tracks they form are afterwards replaced by cicatricial bands, which render the mechanical effect permanent. This little operation is both simple and efficacious. It has the disadvantage, however, of leading to a somewhat unsightly fold of the skin of the lid. Another thread operation, which may be substituted for it on this account, and which is also more suitable in cases in which there is no marked redundancy of skin, is the following:—Two or three loops are formed at the bottom of the conjunctival sac, by passing the two ends of each thread, parallel to each other and close together, from the bottom of the sac upwards underneath the skin, and out immediately external to the lid border, where they are tightly knotted together.

For ordinary senile entropion, however, there is no more immediate and satisfactory cure than the excision of a portion of the lid skin. The thread operations need only be resorted to when the patient is averse to any cutting. When properly done, the removal of skin leads to a permanent rectification of the lid inversion. The only difficulty in the proceeding is to make sure of excising just the right amount of skin. If too little is taken, the entropion, though not as great, may be quite as troublesome as before, and an excision of too large a piece will convert the condition into a more or less unsightly eversion. On the whole, it is better to err on the side of removing too much than too little. At all events, the patient will usually be better pleased. A slight degree of ectropion, amounting as

it does in such cases to little more than a withdrawal of the lid margin from the eye, is of little consequence, provided always there is no decided eversion of the punctum lachrymale. It is well, therefore, to take care not to include too large a piece of skin to the inner end of the lid in the portion excised. In order to get the best effect, the upper limit of the excised portion should come close to the lid margin, except to the inner side, where it should curve away from it. After the slight bleeding has been stopped by pressure, the edges of the wound should be brought together by three or four sutures. The dressing (protective, iodoform, cotton-wool) may be changed after forty-eight hours, the stitches removed, and the linear scar covered by a piece of court plaster. The scar eventually left is quite unnoticeable.

In some children entropion is a congenital condition, and then has quite a characteristic appearance. The lashes, though rubbing against the cornea, do so, not with their points, as in other cases, but are so applied as to be parallel with the cornea, and consequently produce little or no irritation, so that the attention of the parents is generally only attracted to the condition on account of the watering of the eye to which it gives rise. This variety of entropion is probably due to an abnormal development of the orbicularis in the vicinity of the lid margin, and is cured by removal of an elliptical piece of skin.

Another common variety of muscular entropion is that met with in cases where the lid has lost the support of the globe, and this may occur in both upper and lower lids, and be a source of irritation to the conjunctiva. It is seen both when the eye is absent altogether and no artificial eye has been worn, and where there is shrinking of the eye, or *phthisis bulbi*, from any cause.

Cicatricial entropion.—Cicatrices in the conjunctiva, and shrinking of the subconjunctival tissues generally, lead to inversion. The cicatrices may be the result of both accident and inflammation, and this form of entropion is equally frequent in both upper and lower lids, and on the whole more troublesome in the former. The most frequent cause of cicatricial entropion is trachoma. The rubbing of the eyelashes against the eye is not only a source of great irritation, but leads to an aggravation of the corneal inflammation which is so often associated with trachoma; or when originated traumatically, to corneal abrasion, and subsequent ulceration and vascularisation.

The main aim, therefore, in operations for cicatricial entropion is to remove the trichiasis. To do this without sacrificing the

eyelashes, it is necessary to transplant the lid margin. Many different methods of doing this have been practised, few of which can be said to be completely satisfactory, and to fully secure the patient against recurrence as the cicatricial contractions become more and more pronounced. With few and unimportant exceptions, the various methods in vogue may be divided into two classes. In the one, a transplantation is effected by merely loosening the connection between the cilia-carrying border of the lid and the subjacent tissues, and sliding the bridge thus formed upwards, at the same time securing its reattachment in the altered position by suitably placed sutures. In the other, an attempt is made, in addition, to cover the tissues from which this strip or bridge is displaced with a pedicled skin-flap from the lid itself, or with a piece of skin or mucous membrane taken from a distance.

From my own experience of operations for cicatricial entropion, I believe most of the methods which have been advocated are capable of giving fairly satisfactory results. They are, however, in my opinion, not equally suitable in all cases. For instance, the transplantation of a pedicled piece of skin, to fill up the space left bare by an intermarginal incision which detaches the flap containing the eyelashes, is most serviceable in cases of partial trichiasis, where the inversion of the cilia is found only at the outer or inner portion of the lid. For complete trichiasis, it is not only difficult to execute efficiently, but it leaves a decided disfigurement. Transplantation of an unpedicled graft of skin is not to be recommended at all; even if the graft takes, which is by no means always the case, it eventually shrinks, and the effect is lost. Transplantation of mucous membrane from the lid has the same inconveniences, though to a less extent. To get a good result, the portion transplanted must be pretty broad ($\frac{1}{4}$ in. or so). The healing process is a tedious one; the immediate result, a somewhat unsightly broad lid margin, and the subsequent shrinking apt to lead to recurrence of the inversion. Yet several operators who have had large experience of this method of treating trichiasis appear to be well satisfied with it.

For complete trichiasis, without any scarcity of lid skin, and with little incurving of the tarsus, I consider v. Graefe's modification of an old operation (Jaesche-Arlt), on the whole the most suitable. It is easy to do; the healing is rapid, and not interfered with by movements on the part of the patient, who need not, therefore, be confined to bed; and the tendency to recurrence after it is not particularly great, if care be taken

to make a sufficiently deep intermarginal incision. Where, in addition to complete trichiasis, the tarsus is very much shrunken and incurved, it is better, I believe, to substitute another easily performed operation, one which was first recommended by Panas.

All operations on the upper lid are facilitated by being

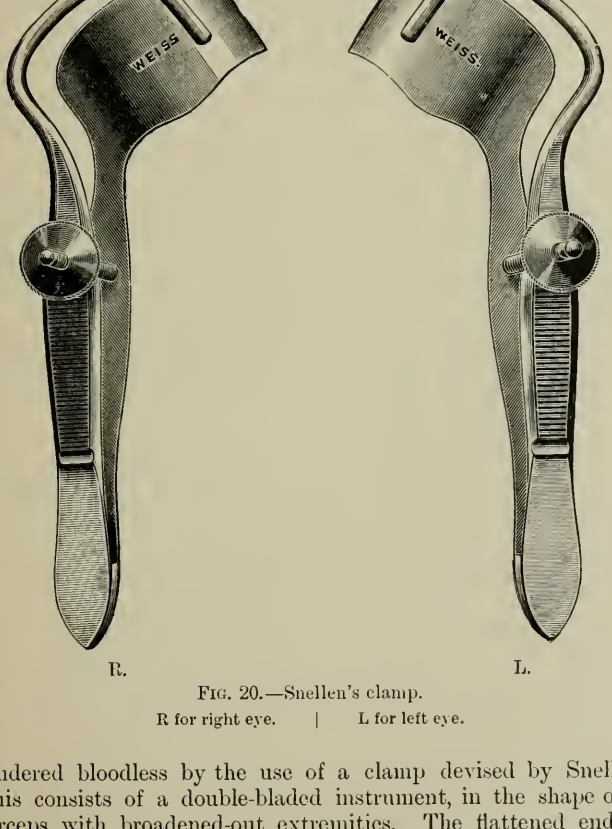


FIG. 20.—Snellen's clamp.
R for right eye. | L for left eye.

rendered bloodless by the use of a clamp devised by Snellen. This consists of a double-bladed instrument, in the shape of a forceps with broadened-out extremities. The flattened end of the lower blade has on the one side a concave cylindrical surface, which is applied to the eye, while its other side, that turned to the inner surface of the lid, is convex. The outer

blade consists of a broad rim, the external measurement of which is rather greater than that of the lower blade. It rests on the skin of the lid, and is screwed down upon the lid, squeezing it on to the one lying between the eye and lid. The rim, when screwed tight, thus completely compresses the tissues and prevents bleeding.

V. Graefe's modification of Jaesche-Arlt's operation is done as follows: After applying Snellen's clamp, an intermarginal incision is made with a fine bistoury, by which the lid is separated along its whole margin into two layers about $\frac{1}{4}$ in. deep. The upper layer must contain the whole of the cilia and their bulbs. At either end of this incision two vertical cuts are made down upon it through the skin, $\frac{1}{4}$ in. or more in length. An elliptical portion of skin is next removed from the surface of the lid. Two or three stitches are then introduced to unite the lips of this wound, the effect of which is to arch up the central portion of the detached layer carrying the eyelashes. Finally, the outer and inner corners of this layer are stitched up to points about $\frac{1}{4}$ in. higher on the other sides of the vertical incision wounds. By this means, traction is exerted on the other portions of the cilia flap. The effect got immediately after operation must be a considerably exaggerated one, as subsequent cicatricial contraction takes place in the site of the intermarginal incision, and the contraction may eventually lead to recurrence if this precaution be not taken.

In Panas' operation the removal of any skin from the lid is obviated. It is done as follows: After applying the clamp, an incision is made through the skin and muscle along the whole length of the cilia-bearing portion of the lid. The incision must run parallel with the lid margin and about $\frac{1}{8}$ in. from it. With a pair of scissors the tissues are then cleared from the tarsus, both upwards and downwards. The upper dissection should extend to somewhat beyond the upper margin of the tarsus, while the lower should just stop short of the lid margin. An incision is next made perpendicularly through the tarsus, at the level of the skin incision, and equal in length to it. This must sever the conjunctiva as well. Threads are then passed through the tendinous attachment at the upper margin of the tarsus, each ends of which are carried down underneath the tissues forming the lid-margin flap, and brought out in the middle of the lid margin. The three or four loops thus laid are tightened and tied over smooth glass beads, to prevent them cutting through the lid margin. The incision in the tarsus thus permits of its lower portion, together with the cilia, being tilted up. The

edges of the skin wound are sufficiently brought in contact by these same loop sutures, the ends of which, after knotting, should be left uncut and plastered down on to the forehead.

Ectropion.—Eversion of the lids, or ectropion, may, from the points of view of both etiology and treatment, be considered as occurring in two varieties—*conjunctival* and *cicatricial*. Conjunctival ectropion can always be satisfactorily treated. Much can also be done for cicatricial cases, but the blepharo-plastic operations, which are required wherever there is a loss of lid skin, are far from giving, as a rule, results which are comparable to those got in the simpler and purely conjunctival cases. Moreover, much depends upon the kind of operation which the particular circumstances of each case render available or most suitable.

In conjunctival ectropion the skin of the lid is either altogether normal, or only slightly eczematous, as the result of being frequently irritated by overflowing tears. It is mainly met with in old people, and then principally, and always, in the marked degrees, in the lower lid. Occasionally one sees a great amount of eversion of the conjunctiva of the upper lid in young children. These cases arise from long-standing conjunctivitis, with great œdema and blepharospasm. They do not call for any special treatment, so far as the ectropion is concerned. This disappears of itself with the subsidence of the other symptoms. The main point to note in connection with conjunctival ectropion is the ease with which the practically normal condition of the skin enables one to hold the lid back in its proper position with one's fingers.

A conjunctival ectropion is only slowly developed. It makes its appearance in cases of old-standing or neglected blepharitis and conjunctivitis. The thickening of the lid margin and swelling of the conjunctiva and subconjunctival tissue, to which this chronic local inflammation gives rise, is further complicated by a deeper infiltration, which impairs the function of the palpebral fibres of the orbicularis muscle. These fibres consequently fail to keep the lid properly applied to the eye, and it becomes everted. With the comparatively slight eversion which occurs at first there is associated a degree of watering of the eye or epiphora. The further increase of the ectropion is then favoured by the hardening and thickening of the everted conjunctiva, the excoriation of the skin caused by the overflowing tears, and no doubt also by more complete loss of power of the muscle fibres.

The *treatment* suitable for cases of *conjunctival ectropion* depends mainly upon its degree. Where the malposition is only

slight, the lower canaliculus should be slit up into the tear sac in the manner elsewhere described. This to a great extent gets rid of the epiphora by admitting of a better excretion of the tears. Any crusts which may be present on the lid margin and on the surface of the everted conjunctiva must also be removed. The conjunctiva is then painted over once daily with a solution of nitrate of silver (5 grs. to the ounce of distilled water), and zinc ointment smeared night and morning along the lid margin, and also rubbed well into the skin of the lower lid.

The same treatment may also be tried in the first place for moderate degrees of ectropion (up to 3 or 4 mm. in depth of exposed conjunctiva). It is generally necessary, however, in such cases to combine with this treatment the excision of some of the swollen and redundant conjunctiva. The portion of conjunctiva removed should equal in breadth that of the everted portion, and should be taken in such a way that the highest-lying everted conjunctiva forms its mid-line. Three or four stitches may then be applied. It is important to remove the conjunctiva well up to the inner canthus.

Higher degrees of ectropion should not be treated in this way, as it is not advisable to cut away too much conjunctiva. Two other methods of treatment, which may be employed either singly or, in excessive ectropion, combined, are then more suitable. These are Snellen's thread operation, and the excision of a triangular portion of the whole thickness of the lid, or of the skin alone, from its outer angle.

Snellen's operation consists in passing loops of thread from the conjunctiva below the skin of the lid in such a way that, on tightening the threads, the everted portion of the conjunctiva is drawn upon and caused to turn inwards. Subsequently the mechanical effect of the threads is, on their removal, maintained by cicatricial bands, which form in the tracks they have made. The steps of the operation are as follows: A stoutish waxed and aseptic silk thread is armed with a needle at either end. One needle is entered at a point midway along the ridge in the conjunctiva which marks the highest part of its eversion. It is then passed outwards, and when felt just under the skin is directed downwards in the subcutaneous tissue of the lid, and brought out at a point 1 in. or more below the lower orbital ridge. The second needle is entered through the same ridge of conjunctiva, and close to the point of entrance of the first (about 2 mm. from it). It is then carried along parallel to the direction of the other end of the thread, and finally brought out close to it. This forms the loop. Two other loops are placed in the

same way on either side of the first. The three loops are then knotted firmly over pieces of drainage tubing. The threads are allowed to remain *in situ* for two to four days, according to the amount of reaction which follows, and are then removed. This little operation, when properly performed in suitable cases, is most satisfactory, and if the canaliculus has been slit, and the treatment of the chronically inflamed conjunctiva continued for some time, there is no risk of relapse. The appearance immediately after removal of the threads is often not very good, as, although the ectropion is overcome, there may be an unsightly degree of thickening of the lid, which at the same time is unnaturally withdrawn from the eye. In the course of a week or two, however, the parts regain a practically normal appearance, the only difference being that the lid skin is not so soft or wrinkled as it normally is.

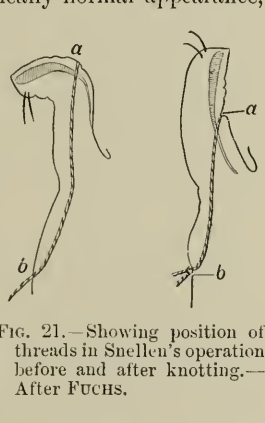


FIG. 21.—Showing position of threads in Snellen's operation before and after knotting.—After FUCHS.

Two points should be remembered in performing Snellen's operation—(1) It is absolutely essential that the threads should be introduced at the highest points of the everted conjunctiva, and not from the bottom of the conjunctival sac, as seems sometimes to be done. (2) Again, the knotting of the threads must not only at the time counteract the ectropion, but must also produce an over effect, and cause a considerable degree of inversion, in order to afford a proper guarantee of a permanently successful result.

With regard to the other operation referred to, as suitable in higher degrees of conjunctival ectropion, it will often be found that there is apparently a redundancy of skin in these cases, and that mere tightening of the lower lid, by pinching up the skin at its outer part, will cause the everted conjunctiva to roll inwards into position. This effect can be rendered permanent by the removal of some of the skin. It is best to remove a piece from the outer part of the lid, and not from the middle as is sometimes recommended. The base of the triangular piece to be removed is formed then by the outermost portion of the lid margin. Two snips with a pair of strong scissors, made from the lid margin, and converging to a point about $\frac{3}{4}$ in. below it, is all the cutting that is required. After the bleeding has been sufficiently arrested, by pressure and torsion, two or three sutures

are applied to bring the lips of the conjunctival wound together, and then a few deeper external ones to unite those of the skin wound. Healing always takes place by first intention, and nothing could be better than the effect of this proceeding, provided a sufficiently large portion of the lid has been removed. It leads more rapidly to a restoration of the normal appearance of the lid than Snellen's thread operation, but has the disadvantage of requiring some experience, in order to be able to estimate properly the amount of tissue which should be removed in order to get the full effect.

In the highest degrees of conjunctival ectropion, as big an effect as can be got, without the removal of too much skin by this operation followed by Snellen's, will rarely fail to give a satisfactory result. In any case where the two operations are combined, they should be done in this order, as the skin excision method requires the absence of any cicatricial formation, to admit of the full effect which can be got from it.

The *treatment* suitable in cases of *cicatricial ectropion* is, as we have seen, influenced by the fact that the eversion of the lid is due to more or less extensive loss of surrounding skin. The operations which have been recommended as applicable in conjunctival ectropion are therefore rarely of use here. They can only be employed in the comparatively slight degrees of cicatricial eversion. Snellen's thread operation, though it may lead to an improvement in such cases, is never particularly satisfactory, as the turning in of the eyelid conjunctiva is then got at the expense of the position of the lid in another respect; it is always too far withdrawn from the eye, which generally causes an unsightly appearance. Removal of a wedge-shaped portion from the lid, on the other hand, sometimes gives quite good results. In cicatricial ectropion, however, the wedge should be removed from the portion which shows the greatest amount of eversion. This may be any part. Often it is the middle of the lid.

As a rule, and whenever the eversion is at all marked, it becomes necessary to perform a plastic operation. The portion of skin which has to be transplanted may be taken from some part in the neighbourhood—from the cheek, the forehead, the temple, the side of the nose, or, in the case of cicatricial ectropion, of the lower lid, even from the upper lid. In all these cases the flap taken should, of course, be a pedicled one.

Sometimes, owing to the absence of any sound skin from which to secure a pedicled graft, a piece of skin completely detached from some other part of the body, preferably the arm or leg, may be used as a graft. This proceeding has the inconvenience

that, although the transplanted skin always, with proper care, retains its vitality, and becomes adherent in the gap to which it has been transferred, it has, nevertheless, subsequently an invariable tendency to shrink to a considerable extent. Often this shrinking is so great, that, notwithstanding that the graft has been taken originally a great deal larger than required to make up for the lost skin, the effect of the operation is gradually practically reduced to little or nothing. After a large experience of such operations, I am convinced that they should never be undertaken except where it is quite impossible to get a flap from any part of the face. The patient should then not be encouraged to expect too much. As there is no local loss of substance resulting from failure in such transplantations, there is always the possibility of repeating them. Indeed, it is usually necessary to do so once or twice, to get a fairly good permanent result. The main points to be attended to in making a large skin graft from a distance are—to secure asepsis in both wound and graft, to avoid interfering too much with the graft, to remove all fat from the skin to be grafted, also any blood clot from between it and the wound, to cut the graft sufficiently large, and to allow the first dressing to remain for six to ten days without being changed.

The first step in the operation should be the freeing of the traction which causes the eversion of the conjunctiva. An incision is made in the skin or cicatricial tissue, parallel with the whole extent of the lid margin and close up to it. This is continued in depth with the knife, or with a pair of scissors, so as to form a flap composed of the conjunctiva, the layer of muscular fibres, and the lid margin. This flap is freed sufficiently to enable the conjunctiva to be easily held in its proper position and turned towards the eye. Three horse-hair loop stitches are then passed through the margins of the upper and lower lids, and the free ends knotted on the lid which is not the site of the operation. This secures the retention of the flap in its proper place, and also fairly well the desired immobility. A gaping wound is thus left, which has to be filled with the graft. Before, however, cutting the graft, a suture may be placed at each angle, and also one or two through the upper edge of this wound, ready to be used for keeping the graft in position. By doing this, any bleeding at the time of placing the graft is avoided. The graft itself is next cut, and of a size at least half as big again as the gaping wound it has to fill. It is best to remove the skin with the underlying fat. This can be done quickly and more satisfactorily than dissecting it free from fat.

The fat is afterwards removed from the excised portion of skin, which is then ready to be placed in position. By the time it is ready, the wound, on which a compress dipped in corrosive solution has been meantime held by an assistant, has usually stopped bleeding. The free ends of the sutures, which have been placed at points surrounding the wound, are then carried through corresponding parts of the edge of the graft, and knotted. These are usually sufficient to hold the graft in its place, but it is well to further secure it against risk of displacement by means of strips of fine court plaster. The whole may then be covered by a piece of ordinary protective, powdered well over, and especially at its margins, with iodoform. A good large pad of

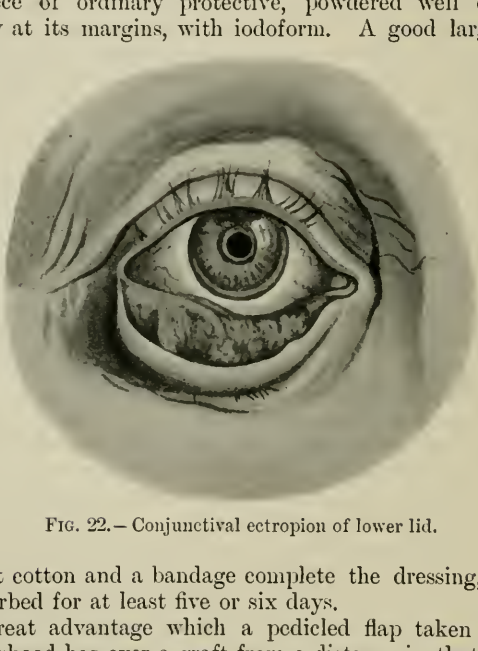


FIG. 22.— Conjunctival ectropion of lower lid.

absorbent cotton and a bandage complete the dressing, which is not disturbed for at least five or six days.

The great advantage which a pedicled flap taken from the neighbourhood has over a graft from a distance is, that it shows little or no tendency to shrink subsequently. When a plastic operation of this nature is properly performed, the flap always retains its vitality. The one objection which might be made is, that a scar is necessarily left at some previously more or less normal part of the surrounding skin. This scar should, however, always be linear, and is then not by any means so unsightly a deformity as that which calls for operative interference. It is important, however, to give quite as much care to the

stitching up of the wound from which the flap is taken as to the stitching of the flap itself into the gap which it has to fill up. Tension must, of course, be avoided, and this is best done by freely undermining the skin before stitching.

The operation must be done aseptically; the ectropion must be reduced completely before the flap is cut, and this either by an incision close to and parallel with the lid border, as already described, or in continuity with a flap, beginning from incisions made at a greater distance from the margin; according to the operation which it is proposed to do. After this the lids should be temporarily sutured together. The flap must be cut suffi-

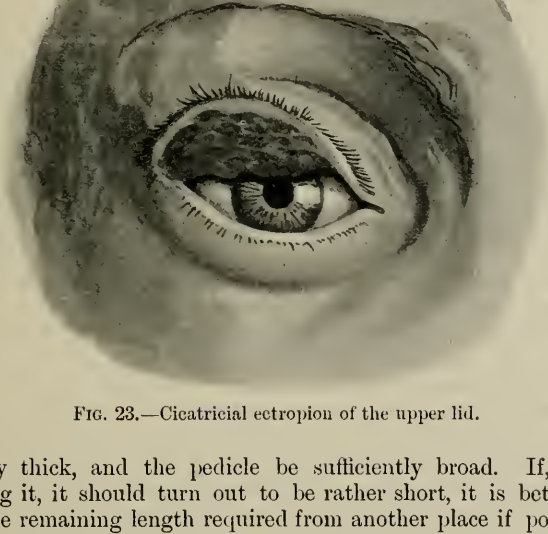


Fig. 23.—Cicatricial ectropion of the upper lid.

ciently thick, and the pedicle be sufficiently broad. If, after cutting it, it should turn out to be rather short, it is better to get the remaining length required from another place if possible, than to risk narrowing the base. If this is not possible, it may be lengthened by undermining the skin at its base. Especially when operating for cicatricial ectropion of the lower lid, care should be taken that the depth of the skin-flap is sufficiently great at the inner angle. Finally, the flap should be very carefully stitched to the edges of the gap to be filled, by a large number of sutures. The dressing should be the same as that described above, but need not remain undisturbed for the same length of time.

A particular form of cicatricial partial ectropion of the lower lid is often met with. This is caused by a tacking down of the superjacent tissues to some portion of the malar bone, which has been the site of a tuberculous caries. In such cases I have found it best to circumscribe by an incision the portion of ulcerated skin or cicatrix which is adherent to the bone. Then undermining the surrounding skin in all directions, but most freely upwards in the direction of the lid, so as to free the ectropion, the wound thus caused may be readily closed, while at the same time the temporary union of upper and lower lids maintains the previously everted portion of the latter in good position. This is better than making an attempt to liberate the puckered skin from the bone, which is not only often difficult to do without buttonholing it, but which almost invariably leads to failure from reattachment.

Epicanthus.—In not a few children, a more or less pronounced fold of skin is found covering the inner angle of the lids, and continuous with the fold normally present on the upper lid. This condition is known as epicanthus. When marked, it gives a peculiar appearance to the face, covering, as it does, most of the white of the eyes to their inner sides. As the child grows, and the bridge of the nose develops, the epicanthus either disappears altogether or becomes much less unsightly; so that it is only in high degrees of the deformity that any interference is called for. In such, too, there is at the same time more or less drooping of the lids, which may be associated with a defect in the power of moving the eyes upwards.

An improvement may then be effected by removing an elliptical piece of skin from the bridge of the nose in a vertical direction, or two pieces on either side of the nose.

Ptosis.—A not by any means infrequent congenital, and often hereditary, defect, due probably, in most cases, to a faulty development of the levator palpebræ superioris, is the drooping of the upper lid, or ptosis, which may be present on one or both sides. Sometimes this is associated with a defect in the upward movement of the eye as well.

Cases have been described, and attention seems first to have been directed to them by Gunn, in which an involuntary raising of the drooping lid has been associated with voluntary movement of the lower jaw. This has usually been on the left side, and has been explained by assuming that the levator is to some extent innervated by fibres springing from the motor root of the fifth.

The effect of ptosis on vision depends, of course, greatly on

its degree; when the pupils are partially covered, the patient is in the habit of throwing his head back in order to see. When this is the case, and still more when the pupil is covered completely in one or both eyes, some operation has to be performed with the object of raising the lid without interfering with its closing.

A curious form of ptosis has been called *isolated bilateral ptosis*. The name was no doubt suggested by the fact that, with the exception of the ptosis, no other demonstrable affection of the eyes or any other part of the body is found in these cases. The ptosis develops so slowly that the patient cannot say when it has begun. It eventually becomes so complete that no action of the levator is possible. In some cases a slight degree of ptosis is apparently present at birth, and afterwards increases in the same gradual manner. The cause is atrophy of levators.

Other forms of ptosis met with are such as are due to partial or complete paralysis of the third nerve—also cases which are merely the result of chronic inflammation of the conjunctiva—mostly trachoma. *Hysterical ptosis*, which may be on one or both sides, is not very uncommon. A peculiar case of slight drooping of the upper lid arises from *paresis of Müller's muscle*. It is associated with myosis, and sometimes with diminished intra-ocular tension, and depends no doubt on some lesion of the sympathetic nerve.

Operations for ptosis.—An operation, the object of which is to permit of the possibility of raising a drooping lid, must of course be performed in such a manner as to interfere as little as possible with the power of closing the lid. Removal of an elliptical fold of skin from the lid can consequently only be employed in cases where the ptosis is of moderate degree, and where there is a redundancy of skin, or at all events the amount of effect produced must be carefully regulated to admit of a sufficient degree of closing. In most cases some other operation will be found more suitable.

After considerable experience of the various operations which have from time to time been recommended, I have found the method devised by Hess the most satisfactory. Of other operations, those of Birnbacher [1] and Eversbusch [2] are also capable of giving good results.

Hess's operation is done as follows: An incision is made along the whole length of the eyebrow, which is first shaved off.

[1] *Centralbl. f. prakt. Augenh.*, Leipzig, 1892.
[2] *Klin. Monatsbl. f. Augenh.*, Stuttgart, 1883.

From this incision the skin of the lid is undermined to close up to the ciliary margin. Three loop sutures are then passed through the skin of the lid from without inwards at about its middle. The ends of each suture are carried below the skin and brought out on the forehead, half an inch or rather more above the incision in the eyebrow. The needles must pass freely in the pouch made below the lid skin, and then be pushed below the skin of the forehead from the upper margin of the incision. The three loops thus made are pulled tight and tied over bits of drainage tubing. A continuous suture is then used to close the eyebrow wound. (See Figs. 24 and 25.)

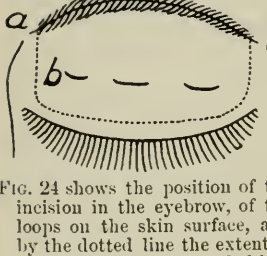


FIG. 24 shows the position of the incision in the eyebrow, of the loops on the skin surface, and by the dotted line the extent of the pouch of undermined skin.

The permanent effect of this operation is got by the healing together of the large surfaces of the pouch. The cosmetic effect is good too on account of the natural-looking fold produced in the lid, and the practical invisibility of any scar when the hair of the eyebrow has grown. The operation is performed aseptically, and consequently no disfigurement need result from the forehead sutures.

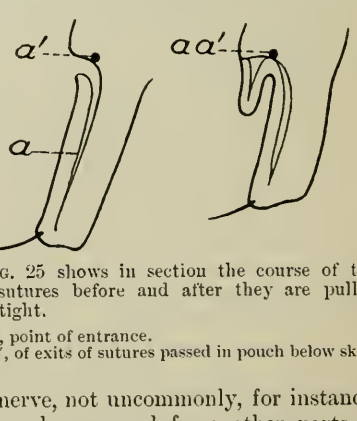


FIG. 25 shows in section the course of the sutures before and after they are pulled tight.

a, point of entrance.
a', of exits of sutures passed in pouch below skin.

Nictitatio.—Constant blinking is often met with, and is known as nictitatio. The cause of this, which is most frequent in children and young adults, is usually some irritation from the eye itself—conjunctivitis or keratitis. Often the irritation originates in some other fibres of the fifth nerve, not uncommonly, for instance, from decayed teeth. It may also proceed from other parts of the digestive tract. At other times the source of irritation is quite obscure, and indeed the blinking is not seldom apparently merely a habit, which has no doubt been originally set up in some such manner as indicated.

If after two or three applications of cocaine to the conjunctival

sac the blinking becomes less frequent, or ceases, it is very probable that the irritation proceeds from the eye; if not, we have to look elsewhere for it—in children, the teeth, or some other part of the digestive system. Often the contraction in the orbicularis is not so general as to cause actual blinking, but is limited to certain of its fibres, mainly those of the lower lid, causing a disagreeable twitch or "twitter" in this region.

Blepharospasm, or spasmodic closure of the eyes, may be constant or intermittent. The constant cases are associated with photophobia, and are discussed in the chapter on diseases of the conjunctiva. The intermittent cases are very rare, and mainly caused by irritation of the facial nerves, which causes, at the same time, other contractions of the facial muscles. In some cases of so-called epileptiform neuralgia, there is painful intermittent blepharospasm.

Œdema of the lids occurs along with inflammation localised in different parts about the face, and is also frequent in affections of the heart and kidneys, where there is any cause for general œdema. In some people there seems to be a tendency to œdema in this situation, independently of any general cause. This is sometimes called *frigid œdema*, and gives rise to a very heavy appearance of the lids, which can be much improved by removing an elliptical piece of the skin of the lid. Occasionally a persistent œdema of the lids is left after attacks of erysipelas of the face. This may, without danger, be treated in the same way, if the patient desires it, for the sake of the appearance.

Long persisting œdema appears to be associated with chronic conditions of inflammation in the mucous membrane of the nose, to which attention should always be directed when the cause is doubtful.

Abscess of the lid is most frequently traumatic, often the result of the breaking down of a blood clot, which has been formed at the time of the contusion. The abscess should be opened and treated antiseptically as soon as fluctuation can be felt. Boils, too, are occasionally met with, principally in the upper lid.

Noma is a form of infectious abscess of the lid which occurs, fortunately only rarely, in children. It begins as a pustule, and leads rapidly to great erysipelatous swelling and redness, followed by gangrenous destruction of more or less of the skin of the lid.

Dermoid cysts are not uncommon in the lids, and are most frequently situated to the temporal side of the upper lid, over

the orbital ridge. They can be removed either by being carefully dissected out, or, through a small opening, by puncture, followed by squeezing out of the contents and removal of the sac with a pair of toothed forceps. The incision must be made in either case parallel with the margin of the orbit.

Nævi of the lids should be treated by electrolysis, if of any size, or if growing; other methods of treatment are liable to cause too much destruction of the tissues.

Rodent ulcers and **epitheliomata** are not infrequently found affecting the lids, and have to be removed. The loss of substance thus sustained may be made good by some suitable plastic or transplantation operation, but in the case of the lower lid this is often unnecessary, as the deformity, after healing has taken place, is often much less than might have been expected.

Chancres and **vaccine pocks** are occasionally found on the lids, being produced in both cases by direct infection of specific matter. The first, from the considerable time which it takes to develop, is sometimes difficult to diagnose; the vaccine pock, on the other hand, is usually characteristic, and the source of infection readily discovered. Vaccinia is more common in women than in men. There is always either a distinct history of inoculation, or of the possibility of inoculation. A child has been vaccinated ten or fourteen days before the patient is seen. Usually the pock occurs on the lower lid, but there are also to be found one or more ulcerated patches on the margin of the upper lid where it comes into contact with the macerated surface of the primary vaccine ulcer. The swelling is always great, and involves not only the lids but also the cheek. The base of the ulcer is decidedly harder than the surrounding swelling; but not so distinctly indurated as in the case of chancre of the lid, and the glands are not swollen. There is, comparatively speaking, very little pain; practically no spontaneous pain, and but little tenderness to touch. The eye itself seems very rarely ever to be affected. I have not seen the cornea involved in the cases, a dozen or more, that have come under my own observation. Vaccinia of the lid never leads to any alteration in its position, and even the cicatrix left is slight—barely perceptible, owing, no doubt, to the laxity of the skin in this situation.

The syphilitic sore is always a more distinctly clean-cut, eaten-out ulcer, which has taken a considerable time to develop from its first appearance as a pimple at the lid margin. The opposite lid margin is not as a rule ulcerated. The base of the ulcer is greatly indurated; and the pre-auricular gland—often,

also, the submaxillary glands—are swollen. There is no history which can in any way connect the case with vaccination, and usually one which renders a syphilitic contagion possible. Secondary symptoms appear in due course.

Sarcoma of the lid is met with as a great rarity in children and young adults.

Other uncommon affections in this situation are *fatty tumours*, *elephantiasis*, *neuroma*, and *coloboma*. The last may occur along with coloboma of the iris. It should be treated as soon as possible, by paring the edges of the slit and uniting them by sutures, so as to secure a proper covering for the cornea.

Blepharophimosis—Anchyloblepharon.—Chronic affections of the lids, especially such as keep up an excoriation of the skin

Fig. 26.—Primary syphilitic sore of upper lid.

at the outer canthus, may lead to a narrowing of the lid aperture, or blepharophimosis. The *treatment* for this is canthoplasty (*q.v.*). When either the complete ciliary margin or a portion of its centre is united with that of the other lid, the condition is known as *anchyloblepharon*.

Symblepharon.—When some injury or destruction of the two opposing conjunctival surfaces of the lid and eye has taken place, there is a tendency for the lids to grow together, and thus give rise to the condition known as symblepharon. This is most likely to occur in all cases where that portion of the conjunctiva, which forms the fold between the ocular and palpebral coverings, is involved in the ulcerative or destructive processes: indeed, it is then almost impossible, except by performing some operation to effect a covering of the raw surface, to avoid their

growing together, as, however frequently the two surfaces be separated, healing will slowly take place from the angle between them.

When the fold is not involved, the frequent separation of the opposing surfaces, by making passive movements of the lid, and at the same time dropping a few drops of oil into the conjunctival sac, will generally permit of their cicatrising independently, and thus obviate the symblepharon.

The severity of the alteration caused by symblepharon is very different, according to the position and extent of the adhesion between the conjunctival surfaces. In very bad cases the eye

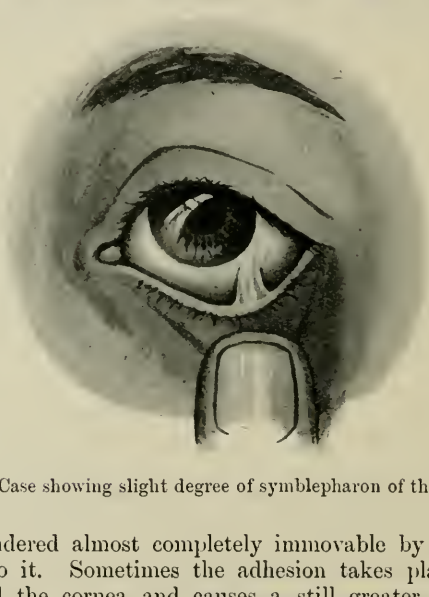


Fig. 27.—Case showing slight degree of symblepharon of the lower lid.

may be rendered almost completely immovable by a gluing of both lids to it. Sometimes the adhesion takes place between the lid and the cornea, and causes a still greater interference with vision than would have resulted from injury to the cornea alone had this not occurred. Adhesions may give rise to diplopia, by interfering with the movements of the eye.

Operations for symblepharon.—The wound left after the detachment of the cicatricial tissue, by which the lid has been rendered adherent to the eye, may be covered in different ways. The method of operation to be selected in any particular case will depend on the extent of this denuded surface, as well as on the condition of the surrounding conjunctiva.

Where the cicatricial band is small and the rest of the conjunctiva healthy, the loss of substance may be made good by a transposition or glissement of the adjoining conjunctiva. The band of cicatricial tissue is grasped firmly with a pair of fixation forceps, and put on the stretch. Its attachment to the cornea is then carefully dissected off with a small bistoury, and the freeing of the lid completed by snipping the other attachments with scissors. The conjunctiva to either side is next undermined to an extent which permits of the edges being readily brought together by sutures. The stitching should be carefully performed, and as many stitches as possible used, particular attention being paid to the covering of the lowest part. Where the

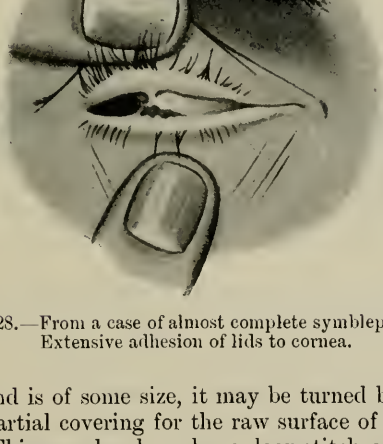


FIG. 28.—From a case of almost complete symblepharon. Extensive adhesion of lids to cornea.

cicatricial band is of some size, it may be turned back and made use of as a partial covering for the raw surface of the inner side of the lid. This may be done by a loop-stitch passed through its apex, then through the thickness of the lid, on the skin surface of which it is tied over a piece of drainage tubing. This latter proceeding is seldom of much use; it is generally better, after cutting away the redundant cicatricial tissue, to rely on the frequent use of oil during the cicatrisation of the lid.

Another operation which is suited to the same class of cases, and by which perhaps a rather large defect can be covered, is *Teale's transplantation operation*. By this operation two flaps of conjunctiva are taken from either side, one of which is used for covering the inner surface of the lid, while the other serves

as a covering for the eye. The flaps are cut as represented in Fig. 29, which is copied from a drawing in Mr. Swanzy's "Handbook of Eye Diseases," altered from his original one by Mr. Teale himself.

The complete transplantation, *or grafting of mucous membrane*, has lately taken the place of other operations for symblepharon. Such a method of operating is certainly applicable to cases which would otherwise not admit of interference. The mucous membrane may be conveniently taken from the mouth, and should be half as large again as the defect which it is to cover, and devoid of any submucous tissue. Owing to the tendency which it has to curl up, it is impossible to get it into good position without the use of a number of stitches. In order, too, to ensure its applying itself to the wound throughout, it is well to put in one or two loop-stitches as well at the fornix, which are brought through the substance of the lid and tied at the outside. The graft

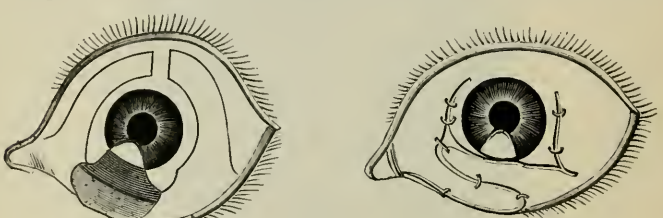


Fig. 29.—Teale's operation for symblepharon.

should not be definitely fixed until all bleeding has stopped; it is therefore best to begin with the stitches that attach it to the lid.

When there is a redundancy of skin in the lower lid, a piece of skin from this situation may be conveniently used instead of mucous membrane, the character of which it to a great extent slowly acquires. It is much more easily fixed in position, and does not require so many stitches. Snellen has recommended an operation for bad cases of symblepharon, which consists in clothing the inner raw surface of the lid, after it has been detached from the eye, with a flap of skin dissected from the temple in the immediate neighbourhood of the outer angle of the lids. After cutting the elongated flap, an opening is made below its base into the conjunctival sac. The skin is then pushed through this opening, so that its raw surface comes to lie against that of the detached lid, and stitches are introduced to maintain it in this position. I have performed this operation several times, and obtained fairly satisfactory results.

CHAPTER IV.

DISEASES OF THE LACHRYMAL APPARATUS.

Affections of the lachrymal gland.—Inflammation of the lachrymal gland is a rather rare affection, which occurs both in an acute and chronic form. The acute inflammation is accompanied by very considerable swelling of the lid and conjunctiva, especially their external portions. The swollen lid is tender to pressure, and through the skin, which is movable over it, can be felt the hard margin of the enlarged gland. Not only does the increased size of the gland cause considerable drooping and more or less complete immobility of the upper lid, but it may also give rise to some protrusion and depression of the eye itself. If it is possible to evert the lid, the lower portion of the swollen gland may be seen pressing forward the fold of conjunctiva forming the transition between the portions covering the eye and the lid. When an abscess forms, it may burst either through the skin or through the conjunctiva; in either case a fistulous opening is likely to result.

The *treatment* should first be directed towards preventing suppuration by means of ice-compresses, counter-irritation with iodine, etc.; but as soon as there is fluctuation an opening should be made, preferably, if possible, through the conjunctiva, as a fistula in that situation is not so awkward as one opening through the skin.

Inflammation of the lachrymal gland sometimes becomes chronic, or may be subacute from the first. Some of these cases are bilateral, and appear to be mostly syphilitic in their nature. The acute inflammation is most frequent in children, and the cause is usually some trauma. In chronic cases, which resist any other treatment, the palpebral portion of the gland may be excised.

Simple hypertrophy or **adenoma of the lachrymal gland** is also met with, and sometimes the gland, though apparently not very much enlarged, sinks down into the upper lid, causing

ptosis. In either case excision is necessary, care being taken not to interfere with the tendon of the levator palpebræ. Fibroma of the lachrymal gland also occurs.

Fistula of the lachrymal gland arises from the bursting of an abscess of the gland. Generally the fistula is an extremely

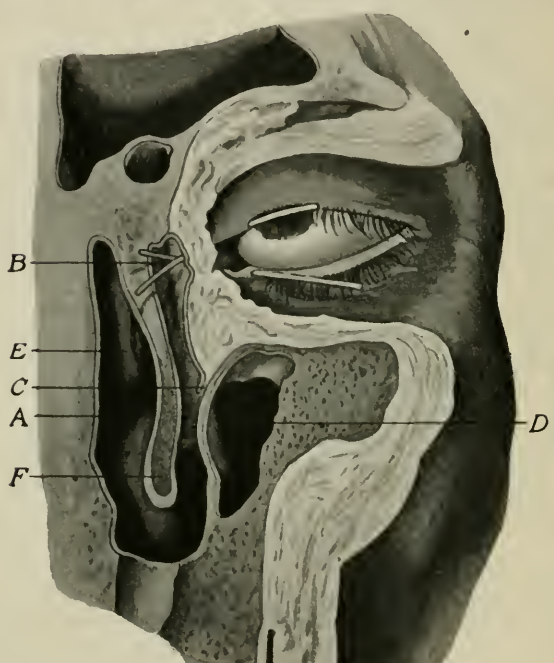


FIG. 30. — Transverse section of face from above downwards and slightly backwards from frontal sinus to first molar tooth. It opened nasal cavity (*A*), lachrymal sac (*B*), nasal duct (*C*), and antrum of Highmore (*D*).
Bristles were passed through puncta and canaliculi into lachrymal sac.
Middle turbinated process (*E*). Inferior turbinated process (*F*).— From a preparation by Dr. Symington.

narrow capillary channel, so that the tears which find their way through it may be little more than fine beads, which evaporate without flowing over the skin of the lid. There is then a tendency for it to close from time to time, and reopen after this has led to some little irritation from surrounding infiltration.

Treatment.—Cases which cause little or no trouble may be left alone. When the skin is much irritated by the tears, an attempt should be made to cure the fistula by means of a wire heated by the galvanic current, or by Bowman's operation, for diverting the opening from the outer to the conjunctival surface. Often any attempt to cure the fistula is unsuccessful, and recourse has then to be taken to partial excision of the gland.

Malignant tumours.—Both sarcoma and carcinoma occasionally affect the lachrymal gland. The diagnosis is usually not easy, as there is at first no difference between them and the simpler forms of hypertrophy. On this account it is better to make a practice of excising the gland in all cases where it is enlarged on one side alone, and the cause is not an acute inflammation. The removal of the gland does not interfere with the necessary supply of moisture to the eye, as, although the tear supply is thus removed, other secretions from the lids suffice for the purpose.

Dacryops, or a clear cyst due to distension of one of the lachrymal ducts with tears, is a rare affection of the lower surface of the upper lid. I have only met with three cases. In one case the cyst entirely disappeared after one puncture. It is generally necessary, however, to keep the opening made, patent for some time, as there is a tendency to reaccumulation. What is probably more efficacious is to remove with scissors as large a portion as possible of the cyst wall.

Diseases of the tear passages.—Affections of the parts connected with the excretion of the tears are of frequent occurrence at all ages, and are consequently of considerably more practical importance than those which involve the secretory mechanism.

The proper removal of the tears down into the nose may be impeded by abnormalities in the structure and position of the canaliculi, by acute or chronic conditions of inflammation of the lachrymal sac, or by strictures in some parts of the lachrymal canal.

Abnormalities in connection with the canaliculi, more especially of the lower ones, on which, under normal circumstances, most of the work devolves, are sometimes congenital, but more frequently acquired. Thus, cases are met with in which the puncta lachrymalia and canaliculi are absent or obliterated. Sometimes there are found supernumerary puncta in connection with other, usually incomplete, canaliculi. In the normal state the puncta are not seen without slightly everting the lids—they are applied to the eye. The tears find their way by capillarity between the lids and the eye to the puncta, being prevented from over-

flowing, when not too copious, by the oily margin of the lower lid. A slight eversion of the puncta, however, without any manifest ectropion, is sufficient to cause epiphora.

Where the condition of eversion is permanent, and not due to some temporary swelling of the conjunctiva, all that is necessary, as a rule, to cure the watery condition of the eye is to convert the canaliculus into an open rill. This little operation was first practised by Bowman, and is now always performed with the narrow probe-pointed knife introduced by Weber. The probe-pointed end of the knife is inserted into the punctum lachrymale (see Fig. 32). The skin, and through it the inner portion of the lid margin, is then put on the stretch with the thumb of the other hand, care being taken to neither invert or evert the lid to any extent. After this has been done, the knife is brought into such a position as to be in a line with the canaliculus as far as possible, whilst its cutting edge is directed upwards and slightly inwards. It is then passed along the canaliculus till its point touches the inner wall of the sac and presses it against the nose. A quick movement round this point as centre is then given to it, upwards if the lower canaliculus is being slit, and downwards in the case of the upper canaliculus. In this way the narrow bridge forming the roof or the floor of the canaliculus is severed up to its entrance into the sac. If the slitting is performed for dacryocystitis, the knife should be passed on into the sac, and, with the cutting edge directed forwards, a slight sawing movement made. The slit canaliculus shows very little tendency to heal up, as union takes place between the skin and mucous membrane to either side of the cut. It is advisable, however, to pass a probe along it after twenty-four hours, so as to ensure its remaining patent. When probing of the duct is necessary, its direction, as shown in Fig. 30, must be borne in mind.

Fig. 31.—Weber's canaliculus knife.

The tears pass more readily into the open channel, and from thence into the tear sac and duct, so that after the slight irritation caused by the cut the overflow ceases.

Wounds of the lid, if they involve the canaliculus, are very apt to lead to some epiphora after cicatrisation. When the patient is seen soon after the accident, care should be taken,

if the edges of the wound have to be brought together, to avoid obliteration of the channel. The simplest way of doing this is to slit up the two portions of the divided canaliculus, and prevent them reclosing by occasionally running a probe along the rill thus formed, until the lid wound has healed.

Sometimes foreign bodies get into the canaliculi, and more or less completely block up the passage for the tears. Occasionally one sees a portion of an eyelash sticking in, and this may, in rare instances, form the nucleus for an incrustation. Concretions that form in this situation have been shown to be mainly fungoid, being made up of masses of leptothrix.

FIG. 32.—Slitting the lower canaliculus with Weber's knife.

Polypi, or rather **papillomata,** occur as a rare disease of the canaliculus. If they show much tendency to grow and cause epiphora, they should be removed. The affection is rather troublesome, and it is not easy to completely eradicate the growths without causing more mutilation than is compatible with the function of the parts.

Inflammation of the tear sac.—The mucous membrane of the tear sac is liable to become inflamed, and this gives rise to either an increase in the normal secretions or to the secretion of abnormal products.

Inflammation of the sac is known as *dacryocystitis*, and may

be of different degrees of acuteness. As the mucous membrane of the sac swells, its lower orifice or passage into the tear duct becomes narrowed or closed, partly by the approximation of the swollen folds of the membrane which are met with in this situation, and partly, no doubt, by the increased mucoid secretion from the swollen surface. The result, in any case, is that the tears do not get properly down into the nose, and by their retention set up further irritation. The secretion, if the inflammation be merely catarrhal, may be mainly or wholly mucoid, and gradually, as it collects, it leads to distension of the sac. This causes a swelling at the inner angle of the eye. Often by pressing firmly on this swelling the mucus can be pressed down into the nose. The mucus may be perfectly clear and transparent, or more or less turbid from the admixture of pus cells.

The most common form of inflammation of the sac is a chronic blennorrhœa, in which, along with epiphora, there is no marked distension of the cavity, but in which, on pressure over the sac, some thin purulent matter escapes as a rule by the canaliculi.

Acute purulent dacryocystitis generally causes œdema of the eyelids, which, if considerable in amount, may altogether mask the local swelling, so that anyone unaccustomed to see such cases might well imagine that the lids or the periosteum round the border of the orbit was the site of the inflammation.

The *diagnosis* can readily be made by determining, on pressure with the finger, the point of greatest tenderness. In dacryocystitis no pain is felt until pressure is made over the sac, where even the slightest pressure is often exceedingly painful.

In some cases of acute inflammation of the sac, healing takes place without any bursting of the abscess; but in many the skin over the sac becomes more and more thinned, and eventually gives way. This usually takes place at a somewhat lower level than the sac itself after the tissues above have been infiltrated —at the most dependent part, therefore, of the superficial abscess thus formed. The result of this is that there is a passage of some length formed between the external and internal openings, which has a tendency to become fistulous. Sometimes a more or less extensive necrosis of the skin takes place, so that an ulcer is established in this situation, which may lead to cicatricial ectropion of the lower lid.

Dacryocystitis is most frequently set up by an inflammation originating in the mucous membrane itself, and is probably as a rule the result of extension of a similar condition from the

mucous membrane of the nose, only increased in severity by the irritation which the retention of the secretion produces. Sometimes it appears to be primarily associated with disease of the bone or periosteum, which is then of a strumous or syphilitic nature. The ordinary inflammation beginning in the sac rarely, if ever, spreads to the bone; so that in cases where the bone is found to be diseased, and not merely bare, which may result from rough treatment, such disease must be looked upon as the primary affection.

A correct idea of the etiology of inflammation of the lachrymal sac is of importance in suggesting a suitable plan of treatment. There can be little doubt that by far the largest

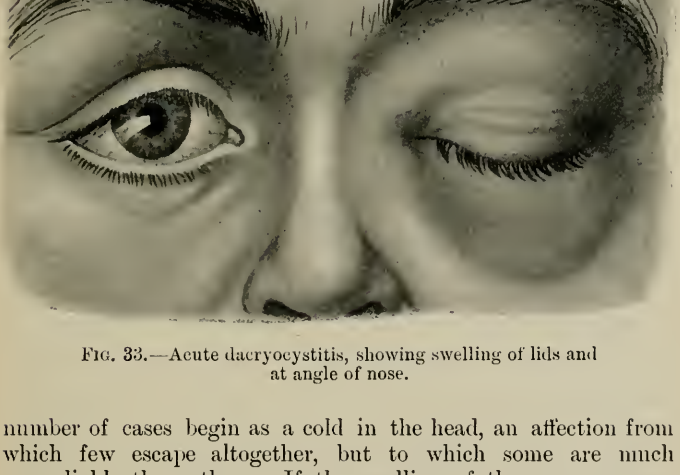


FIG. 33.—Acute dacryocystitis, showing swelling of lids and at angle of nose.

number of cases begin as a cold in the head, an affection from which few escape altogether, but to which some are much more liable than others. If the swelling of the mucous membrane of the lachrymal duct persists for long, there is a tendency, when any individual predisposition exists, to the stagnation and decomposition of the secretions in the sac, which becomes more and more pronounced the more its anterior wall becomes distended. This sets up an irritation, and leads, as a rule, to blennorrhœa of the sac, which may be more or less pronounced, and which is liable at any time to pass into the acute form of dacryocystitis. When this takes place there has often been a fresh coryza shortly before. Often, no doubt, the acute

phlegmonous inflammation which succeeds the mere catarrhal change in the mucous membrane is the result of a deeper penetration of the microbes and toxins. It is remarkable how seldom any complication in the sac is met with in cases of purulent conjunctivitis.

The secretion which passes into the conjunctival sac from the abnormally inflamed tear sac is not infectious to the conjunctiva, and rarely leads either to purulent inflammation of the conjunctiva or to conjunctivitis if transferred to the other eye, though it is more or less irritating to the lid margin, and thus gives rise to blepharitis. It possesses, therefore, none of the virulence of the pus which is found in a case of gonorrhœal conjunctivitis. Nevertheless, it is well known to be a source of great danger when any operation is performed on the eye, and the cause in many cases of the septic hypopyon ulcer which follows slight abrasions of the cornea.

By many, strictures of the duct are looked upon as the immediate exciting cause of dacryocystitis; yet it is remarkable in what a large proportion of cases probes can be passed with the greatest ease when once the sac has been opened into. Many cases of stricture, where the stricture is far down at the entrance of the duct into the nose, do not give rise to inflammation of the sac; and as for the strictures which are met with in the other situations where they are common, namely, at the lower orifice of the sac, these are almost invariably the consequence of the destructive inflammation of an acute dacryocystitis, and not its cause.

The *treatment* of blennorrhœa of the tear sac should aim at preventing the occurrence of acute phlegmonous inflammation, and stopping as far as possible the interference with the discharge of the tears. The first, however, is the more important; but as many cases are first seen when the stage of acute inflammation has already begun, it is also necessary to consider the proper course of treatment to be adopted under such circumstances.

As soon as the existence of a chronic blennorrhœa has been diagnosed, active treatment should be begun without delay. This should consist in making an opening into the sac from above, through one or both of the canaliculi, probing the duct from time to time, so as to maintain its patency, and by astringent and antiseptic injections modifying, as far as possible, the character of the secretion from the mucous surfaces.

The choice of which canaliculus to open is perhaps hardly a very important matter, still there are good reasons for preferring

the upper. In the first place, the lower is then left in its physiological state, and as it has most to do with the removal of the tears, this may be some, though possibly only a very slight, advantage. A more practical consideration is the circumstance that the upper canaliculus is in a more direct line with the duct, so that probes can be passed without stretching the tissues at the opening into the sac to the same extent as is often done when the lower canaliculus is opened, and which may lead to cicatricial contractions in this situation, and consequently to a complication which is apt to prove troublesome.

The canaliculus should be freely opened into the sac and the knife passed into the sac itself, with the cutting edge directed forward, and then made, by a slight sawing movement and slight rotation on its axis to either side, to freely divide any constricting bands which are present in this situation. After this has been done, a medium-sized probe should be passed down the duct into the nose. As has been already said, the probe can usually be passed without the slightest difficulty. By this treatment a great improvement usually takes place in the course of two or three weeks, but the length of time during which the treatment has to be continued depends a good deal on the chronicity of the case. The reason of this seems to be the tendency to greater and greater distension of the sac, and consequently a greater likelihood of stagnation taking place in it the longer the case has continued. There is a pretty general tendency to do too much. This appears to arise from too great importance being, as a rule, attached to the blocking of the tear duct as the cause of epiphora, and to a too general assumption that the blocking is of the nature of a stricture. It should be remembered that it may possibly be a questionable advantage to maintain the patency of the duct at the expense of frequently bruising and otherwise irritating its mucous lining.

The two consequences which, in my experience, are apt to follow the use of very large probes and of repeated probing are (1) the conversion of a blocking, from mere catarrhal swelling of the mucous membrane, into a blocking from actual submucous stricture, and (2) the tendency to provoke a dacryocystitis. The latter would possibly be more frequent than it in reality is from such treatment, were the mucous membrane of the sac bruised to the same extent as that of the duct.

Another very frequent result of excessive probing is the production of a stricture at the canaliculus entrance to the sac. This is especially caused by large probes, and more particularly

when the opening along the canaliculus has not from the first been prolonged well up to the sac. The raising of the probe, which is necessary to cause it to descend into the duct, constantly overstretches and even lacerates the tissues, and thus this troublesome form of stricture arises. Owing to the tendency to this disagreeable complication, it is preferable to open the upper instead of the lower canaliculus.

Sometimes the slitting of the upper canaliculus presents considerable difficulty. In these cases, and always where there is any ectropion of the lower lid, the lower canaliculus should be slit. The opening got by slitting the upper canaliculus is not so ample, and does not admit of the use of very large probes.

As regards epiphora, it is interesting and instructive to note the differences commonly met with in the ordinary cases of blennorrhœa of the lachrymal sac when compared with cases in which there is a complete obliteration of any channel for the excretion of the tears. In all blennorrhœa cases the epiphora is more or less constant and very troublesome. Yet in the vast majority of such cases there is no difficulty experienced in passing a good-sized probe down the duct. After thorough obliteration without catarrh or after complete removal of the sac, on the other hand, there is almost invariably little epiphora. Not infrequently this symptom is practically absent. It is clear, therefore, that faulty excretion cannot be the main cause of the symptom, for the removal of which one is mainly called upon to interfere. In fact, there can be little doubt that much of the epiphora is due to excessive secretion of tears, caused by an irritation which originates in the mucous membrane of the sac, and possibly also of the duct.

The consideration of these facts affords one a guide to a rational treatment. And the first point that suggests itself is this: is it necessary, in order to bring about a return to the normal condition of the mucous membrane, to attempt to maintain a constant patency of the duct?

No doubt stagnation and decomposition of the mucous secretions and other products in the sac is greatly, if not entirely, the cause of the continuance of the state of irritation. The opening of the duct by probing, not unreasonably, therefore, appears to be indicated to overcome this stagnation. As, in addition, there is always the risk of a catarrhal inflammation in the sac developing into a phlegmonous acute dacryocystitis, there can be no question that the sooner attempts are made to check stagnation the better. As soon as we have occasion to

diagnose blennorrhœa of the sac, by finding more or less regurgitation through the canaliculi on pressure over the sac, a canaliculus should be slit, preferably the upper, for reasons already stated, and the duct probed. The object of this proceeding should not, however, be to bore, as it were, a passage for the too copious overflowing tears, but rather to hasten the recovery of the mucous membrane and to remove the risk of dacryocystitis. This being the case, the frequency and severity of the manipulations required will be determined solely by the extent to which the mucous membrane will tolerate the necessary interference.

In my experience there is too much risk entailed by the use of both very small and very large probes. The former are apt to cause laceration, the latter bruising. Too frequent probing, even with the sizes of probe such as I have found most suitable (one of a diameter of a No. 6 Bowman to one of 1·75 mm. diameter), also generally defeats its object by irritating the mucous membrane too much. Probing should be done at intervals of a fortnight to begin with, and then, if necessary, at longer intervals. Generally, however, three or four probings are sufficient; nearly always so, if the case has come under treatment early.

Syringing the duct, which is often recommended, is, as I have found after a very extensive trial of it, no more effective than simple probing.

There is one class of case, however, in which syringing is useful. This is the condition in which the sac has become over-distended, and fills up with mucus or muco-pus, notwithstanding that a probe passes quite readily down the duct. In this rather troublesome complication syringing the sac alone freely with sterilised water until all the secretion is removed, and then with a 10 per cent. solution of protargol or argyrol, is certainly useful. A carefully applied pad of cotton-wool may with advantage be used afterwards to check the refilling of the dilated sac. These syringings should be repeated daily. The treatment is, in fact, much the same in principle as that for cystitis caused by an over-distended bladder, and, though it may have to be continued for some time, is, on the whole, very successful.

The treatment for epiphora due to catarrhal inflammation of the sac, which consists in early opening through the upper canaliculus, followed by probing with a moderate-sized probe at intervals of a fortnight, is almost invariably satisfactory, and leads to rapid improvement or recovery. It is otherwise, how-

ever, with cases which have gone on to dacryocystitis before treatment has been begun. They very often prove more troublesome. My experience of such cases, which are unfortunately far from uncommon, is that it is far safer to avoid probing altogether until all acute symptoms have subsided. If the case be seen before the tissues in front of the sac wall have become infiltrated, an opening should be made through both upper and lower canaliculi.

When an abscess has actually formed, sufficient drainage can only be got by an incision through the skin into the sac. The incision should be free, and be made in a line with the duct, but should not be begun too high up, so as not to involve the palpebral ligament to any great extent. It is a good plan to stuff the opening thus made with iodoform gauze, and to continue this method of dressing until the discharge has practically ceased, or the inflammation of the tissues has subsided.

A single simple incision, not followed by any attempts at draining, or at best by a poultice or wet antiseptic dressing, is no doubt sufficient in some cases. As a general rule, however, it does not seem advisable to rely upon this. Cases which are allowed to heal slowly are most likely to do best in the long run. In most of them the epiphora eventually passes off, or is so slight as to cause little trouble. As, however, there is a risk of recurrence at some time or other, it is a good plan after the dacryocystitis has disappeared, to slit freely either one or both canaliculi. This need only be followed by probing if there is much epiphora. Usually the passage of probes in such cases presents more difficulty than in cases of simple blennorrhœa of the sac. This is owing to loss of substance, followed by fibrous stricture at the lower opening of the tear sac. In fact, it is, with possibly a few exceptions, only where there has been a dacryocystitis that any real stricture of the duct is met with naturally. But where large probes, too frequent probing, and styles have been used for epiphora due to blennorrhœa alone, a stricture not infrequently results.

In the presence of a stricture, naturally or artificially produced, a certain degree of forcible probing is probably quite justifiable. And here I have found conical probes the most efficient. These should not, however, either be too large or passed too frequently. It is often necessary, however, to continue fortnightly probings for much longer than in the treatment of simple blennorrhœa. Whether it is advisable to go on for months with this treatment or not will depend greatly upon its effect. If it keeps down the epiphora, nothing else need be done. * If, on the

other hand, the epiphora continues to be very troublesome, or still more, if a subacute state of dacryocystitis persists or frequently recurs, complete removal of the tear sac is unquestionably the most satisfactory treatment.

Dacryocystitis treated in the manner just described is, with rare exceptions, either slowly recovered from without any probing being required, or only leaves a degree of epiphora, which is greatly improved or cured by the occasional use of probes. Cases of dacryocystitis which have burst spontaneously and afterwards remained untreated, are apt to be much more troublesome. They not infrequently leave a fistula, and, it may be, a sort of lupoid scabbing over and round the site of the opening in the skin. They also much more frequently recur or remain chronic. In a considerable proportion of cases which have this history, removal of the sac is the best treatment to follow. An attempt should, however, first be made to treat them on the same lines as that described for cases first seen at an earlier stage.

The lupoid scar tissue, if present, should be thoroughly scraped away with a Volkmann's spoon before a free vertical incision is made into the sac. Where only a fistula without any marked inflammation remains, this may be treated by the actual cautery, the point of a small thermo-cautery or galvano-cautery being passed down the fistula, and the canaliculi slit. Large probes, frequent probings, and the use of styles are, in my opinion, to be avoided. Removal of the lachrymal gland, or any portion of it, which some recommend, is altogether uncalled for.

The affections of the lachrymal sac and duct are of very great practical importance, not only on account of their frequency, but also because of the dangers to which the eye is thereby exposed. A very large proportion of cases of one-sided blindness are cases of dense leucomata, following hypopyon ulcer of the cornea; and that, again, is in a large percentage of cases the result of infection from a blennorrhœa of the sac. A very considerable proportion, too, of the cases in which destructive inflammation of the corneal wound occurs after operations have the same infectious cause.

CHAPTER V.

DISEASES OF THE CONJUNCTIVA.

The normal conjunctiva.—Very considerable differences exist in the appearances presented by the healthy conjunctiva. There are differences in vascularity, differences in the fulness and thickness of the transition fold separating the palpebral from the ocular conjunctiva, and differences in the smoothness of surface. It often happens that perfectly healthy conditions of the conjunctiva are taken for inflammatory even by those who have had considerable experience of eye diseases. This is often, as might be supposed, the case when the subjective symptoms are more or less suggestive of conjunctivitis, but the mistake may also be made even when, in the absence of any symptoms, some chance has led to an examination of the lids.

The vascularity of the conjunctiva is not only subject to individual differences, but varies at different times in the same individual. The appearances presented in this respect depend upon both local and general conditions. Exposure to strong light, prolonged use of the eyes for reading or other work close at hand, especially reading with insufficient illumination, cause temporary hyperæmia. The same condition of course follows rubbing of the eyes, the irritation of some foreign body, dust or smoke or impure atmosphere. It is also a necessary accompaniment of emotional disturbances which lead to weeping.

Further, any cause which gives rise to congestion of the vessels of the face, such as indigestion, stooping, etc., is also followed by conjunctival congestion. In general anæmia, on the other hand, the conjunctiva is often distinctly pale, though the existing poverty in hæmoglobin is usually more readily seen in the colour of the gums.

The conjunctival fold, particularly that of the lower lid, is very different in different people. The difference depends in great measure upon the subconjunctival tissue. In some people the conjunctiva in this situation appears more plentiful and is

thrown into a greater number of lax folds than in others. In some, again, as the lid is everted, the fold springs into view as a more stretched and apparently less vascular covering to the mass of more or less dense and hard subjacent tissue.

In most adults the surface of the conjunctiva is smooth, or there are to be seen, only here and there and especially in the fold of the lower lid, small and irregularly triangular-shaped eminences—follicles. In young people, on the other hand, it is the rule to find more evidence of these prominent follicles. In many children, indeed, the follicles may be seen in considerable numbers arranged along the ridges of the folds in the retrotarsal section of the conjunctiva of the lower lid, and often also at the outer and inner portions of the conjunctival membrane covering the upper border of the tarsus in the upper lid. Even an excessive development is far from uncommon in children. Certainly those accustomed to see only the conjunctiva of adults might well imagine that the appearances then presented were pathological. In point of fact, however, this adenoid overgrowth, on account of the absence of any accompanying symptoms, as well as of its frequency, can hardly be looked upon as pathological. It is probably of the same nature as the adenoid hyperplasia which is so common in the naso-pharynx in children, and, like that, always disappears more or less completely with growth.

Congestion of the conjunctiva.—When congestion of the conjunctiva persists, it must of course be considered pathological. This condition gives rise to symptoms which, according to its degree, to its causation, and also to individual temperament, are variously described. Some complain of a hot, burning sensation in the eyes, others of a feeling as if there were sand in them. The eyes feel heavy and tired, or are weak and watering. All such symptoms, too, may be aggravated by exposure to light of an amount which under normal circumstances would cause no inconvenience.

The causes of conjunctival congestion are both local and general. Direct irritation may be caused and kept up by noxious gases or fumes, by minute particles of irritating substances, or by prolonged exposure to strong light. There is usually something in the occupation or habits of those who suffer from congestion due to any such irritation, which, when inquired into, will lead more or less conclusively to the discovery of the cause. Permanent conjunctival congestion arising in this way is, however, not very common.

A more important local cause of congestion of the conjunctiva

is some error of refraction. Slight astigmatism, hypermetropia, and less frequently myopia, when uncorrected, often lead to a more or less involuntary semiclosure of the eyes and frowning, by which the sight is improved. This pursing up of the eyes and frowning, however, by pressure on the cornea, and especially in astigmatism, where such pressure has the effect of correcting, more or less completely, its abnormal curvature, often leads to irritation.

In most, though not all, cases where the cause of congestion is in the first place an error of refraction, the symptoms are all aggravated by the use of the eyes for near work, as it is mainly then that the unconscious effort to correct the refractive error is persisted in.

Another cause of conjunctival congestion which may perhaps also be looked upon as local is the participation of the membrane in a hyperæmia which has its origin in the naso-pharynx.

What may be classed as the general causes of hyperæmia of the conjunctiva are probably numerous, and such as lead to both active and passive congestion—the absorption into the blood of different toxins, the accumulation of uric acid and oxalates, etc. A large proportion of cases of slight conjunctival congestion, in which the symptoms complained of seem out of all proportion to the local circulatory changes, are of a gouty nature. Not unfrequently, too, hyperæmia seems to be kept up in connection with constipation, and may then presumably be either active, from the irritation of absorbed toxins, or simply passive, or both combined.

In all cases in which the congestion met with in the conjunctiva is due to general as opposed to local causes, there are other symptoms, such as indigestion, headache, vertigo, etc., to which attention has to be directed before the real cause can be established; and although the symptoms may be aggravated by the use of the eyes for reading, or near work of any kind, this is not so invariably or so distinctly noticeable as in that arising in connection with refractive errors.

Treatment of conjunctival congestion.—In all cases where the congestion is evidently due to some external irritant, the treatment should of course mainly consist in, as far as possible, removing the cause. In addition, hot sponging and occasional bathing with a mild antiseptic—preferably a 2 per cent. solution of boracic acid—may be used. Strong antiseptics, cold compresses or poultices of any kind, or astringents, must be avoided. Often, and particularly where the congestion has been set up or aggravated by exposure to strong light, dark (neutral-tinted)

glasses may be used out of doors, or at work when the nature of the work entails subjection to strong illumination. Blue glasses, as they do not, although absorbing some light, sufficiently shut out the chemical (actinic) rays, which are the most irritating, are not so suitable.

In all cases of persistent congestion the state of refraction should be examined into, and hypermetropia or astigmatism be properly corrected. More especially is this advisable when there is a habit of frowning while reading. Even although an existing error of refraction may not have been the principal cause in originating the state of congestion, it may often contribute more or less towards keeping it up. Apparently even slight degrees of astigmatism, which do not appreciably lessen the visual acuity, so far at least as can be detected by the ordinary tests, may, when associated with frowning and other unconscious efforts at correction, by lid pressure, help to keep up hyperæmia. Correcting glasses should therefore be used for reading.

Where the presence of congestion does not receive a satisfactory explanation from any refractive error or the exposure to any external irritant, it is often accounted for, as has been said, by some derangement in general health. Attention must then be given to diet, to the action of the bowels, to exercise, etc. It is often useful to restrict the allowance of farinaceous food, and to have animal food taken finely minced, and not too much cooked. In many cases where there is other evidence of gouty irritation, some preparation of lithia, such as the citro-tartrate, taken between meals, and also colchicum, is most useful. By such therapeutic and dietetic treatment the symptoms are often very quickly overcome. Sometimes a nasal douche may be used with advantage when the conjunctival congestion is but one element of a more extensive hyperæmia—in hay-fever, for instance.

The great point to bear in mind always in all cases of simple conjunctival congestion is, *not to over-treat locally*. Especially is it advisable to avoid astringent lotions of all kinds. The tendency to abuse in this direction is very common. Indeed, the principal cause for the persistence of the congestion in many cases one sees, is in reality the treatment to which they have been subjected.

Conjunctivitis.—When, in addition to hyperæmia, there is marked increase and alteration in the conjunctival secretions, the case must be looked upon as an inflammation—conjunctivitis.

A clinical division of the different varieties of conjunctivitis may be made, in the first place, into those which are not

followed by any destruction of tissue and subsequent cicatrisation, and those which are complicated in this way. Of the first group, in which, after recovery, there is a complete return to the normal condition, we may distinguish two classes, according to the nature of the secretion from the inflamed conjunctiva. In the first, the secretion is muco-purulent, and there is comparatively little or no general swelling of the lids. In the second, the discharge is decidedly purulent, and the inflammation of the conjunctiva is accompanied by considerable, often by excessive,

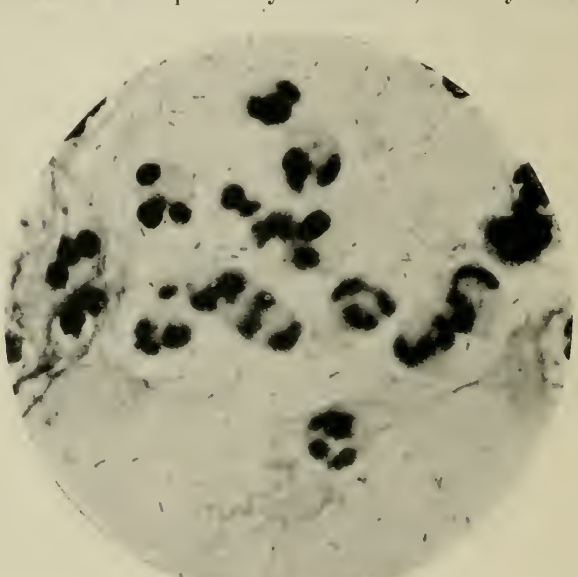


FIG. 34.—Showing Koch-Weeks bacilli, from a case of conjunctivitis. (×1000 diams.)

swelling of the lids and subconjunctival œdema — so-called *chemosis*.

There are no doubt many varieties of muco-purulent conjunctivitis. There is, however, not much difference in their clinical aspects. Cases of this nature are for the most part, though probably not invariably, set up by the pathogenic action of definite and different micro-organisms. Several different microbes have been shown to cause conjunctivitis. This has been demonstrated by their constant detection in the secretion

from the inflamed conjunctiva, and also by direct inoculation of the healthy conjunctiva with pure cultivations of the microbes. The main clinical differences which appear to characterise the inflammation resulting from different specific germs are—differences in the severity and duration of the inflammation, and in the extent to which eczematous thickening of the skin of the lid or of the lid-margin is associated with the conjunctivitis.

While, therefore, no doubt, a scientific classification of conjunctivitis cases might be based upon bacteriology, the clinical

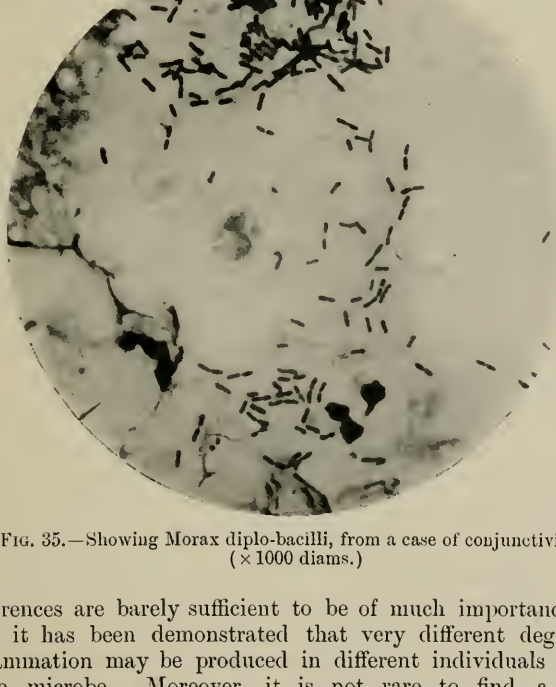


Fig. 35.—Showing Morax diplo-bacilli, from a case of conjunctivitis. (× 1000 diams.)

differences are barely sufficient to be of much importance. In fact, it has been demonstrated that very different degrees of inflammation may be produced in different individuals by the same microbe. Moreover, it is not rare to find a mixed infection. The main point to bear in mind is *the frequency altogether of some microbic origin.* The Koch-Weeks bacilli and the pneumococci and pneumo-bacilli are perhaps the most frequently met with as the causes of epidemics of conjunctivitis. The former is characterised, when uncomplicated, by the ocular

conjunctiva being mainly implicated, and by the frequency of small ecchymoses in this situation. The Morax diplo-bacilli give rise to an acute conjunctivitis, which has a tendency to become chronic, but which readily yields to treatment with zinc preparations. Clinically this cause may be suspected where a chronic conjunctivitis is associated with blepharitis and eczema confined to the region of the outer canthus.

In the ordinary muco-purulent or *catarrhal conjunctivitis* there is more or less thickening of the conjunctiva, with swelling and increased fulness of the folds. This, with the greatly increased vascularity, gives rise to a more equable red coloration. An eruption of a number of very minute vesicles on the tarsal surface causes an appearance as if the conjunctiva were strewn with sand, which, when associated with much hyperæmia, gives it a velvety look. There is on the whole a tendency for the hyperæmia to be confined to the palpebral conjunctiva. When, however, it also involves the ocular portion, it is always most marked in the periphery, diminishing in intensity towards the corneal margin. This is a point which should specially attract attention, as, when the cornea, iris, or deeper parts of the eye are inflamed, the hyperæmia is, on the contrary, most intense in the circumcorneal zone, where the deeper and closer network which springs from the anterior ciliary vessels is injected. An absence of any diminution of injection of the white of the eye in the neighbourhood of the cornea should always, in a case of conjunctivitis, arouse suspicion of some corneal complication.

The secretion from an acutely inflamed conjunctiva is at first so preponderatingly composed of tears that it is distinctly watery. Only gradually, and after a day or two, does it assume a more viscid, and eventually more definitely muco-purulent, character. The constant overflow of tears and of the more copious and altered secretion causes excoriation of the skin. The skin surrounding the outer canthus especially usually soon comes to have a raw, macerated appearance. When the eyes have been kept closed for some time, and therefore in the morning after sleeping, the lids are glued together by the retained secretion which has dried upon the eyelashes.

The subjective symptoms in an ordinary acute case of muco-purulent conjunctivitis are: sensitiveness to light, tiring of the eyes on reading, and a hot, burning feeling in them, which, in severe cases, and in particularly sensitive subjects, may even amount to more or less violent pain.

The duration of an attack is very variable. The severer

symptoms generally only last a few days, but may continue for weeks. As a rule, when recovery is not fairly complete in a fortnight, the treatment has been the cause of the delay. No doubt some cases have a tendency to be prolonged, altogether independent of treatment.

The early recourse to astringents, such as alum and sulphate of zinc, is a very common cause of aggravation. The same may be said of poulticing, which, if continued for any time, may have, however, much worse consequences. The relief from pain which is afforded by poulticing at the beginning not unnaturally gives rise to the belief that such treatment is beneficial. Continued poulticing greatly increases the swelling and vascularity, and also, by favouring the growth and multiplication of different germs, which are more or less constantly present in the conjunctival sac without doing harm, make these a source of danger. In addition, therefore, to the effect of one specific germ, which may cause but an unimportant reaction of no great duration, further inoculation by others of a more virulent type is apt to take place. Even iced compresses, which are so frequently recommended, more often do harm than good. This depends to a great extent upon the manner in which they are usually applied, namely, as compresses laid upon ice, and then transferred to the eye, and frequently changed. To get the proper effect from ice, which in any case should only be used at the beginning, and before the secretions have become altered and increased, the temperature of the compress must always be maintained at the freezing-point. This can be done by running iced water through a coiled tube resting on the compress. It must always be borne in mind, however, that where there is any corneal complication ice applications are dangerous. On the whole, there is no advantage to be gained by ice which cannot just as well be got by the efficient use of antiseptic lotions.

Acute catarrhal conjunctivitis is rarely complicated by any corneal inflammation. Occasionally small superficial ulcers—"catarrhal ulcers"—form on the cornea in the course of a conjunctivitis. They occupy a position close to, but almost always a little removed from, the corneal margin. When close together, two or more may become confluent. They have a tendency, as a rule, towards rapid healing.

Besides the constant blinking and photophobia from which patients with conjunctivitis suffer, they often complain of temporary obscuration of vision, or of seeing haloes or rings round lights, or sometimes of polyopia. All these appearances are due to little collections of secretion in front of the cornea, which

produce alterations in the refraction of the rays of light entering the eye. They disappear on rubbing the eye, but in many cases quickly reappear.

The secretion from a catarrhal conjunctivitis is certainly contagious if the affection is acute, when it is muco-purulent in character. In the more chronic forms there are probably considerable individual differences in this respect; but, on the whole, the discharge in such cases is not by any means markedly contagious.

In the *treatment* of conjunctivitis in the acute stage, the principal point to attend to is not to interfere too energetically. There is a danger in doing too much. All that is necessary in most cases is to freely remove the secretion during the day, and to prevent its too great retention within the conjunctival sac at night. Even those who are sufficiently alive to the disadvantages of an active treatment with astringent lotions, rarely seem to take care that the more suitable mildly antiseptic or other bland lotion which they employ is so used as to properly irrigate the inflamed conjunctival surface. An efficient removal of discharge is not got by merely squeezing a little lotion from a sponge or piece of cotton-wool into the lower conjunctival sac, or by using an eye-bath. In very many cases, however, the tendency to a speedy return to the normal in the absence of irritative treatment is so great, that this is not of much consequence. It certainly, however, is a better plan to irrigate properly. This may be done by allowing a pint or more of the lotion (preferably a 2 per cent. solution of boracic acid at a temperature of 90° to 98° F.) to stream by gravitation over the whole surface of the conjunctiva three or four times daily. For this purpose the vessel containing the liquid may be held 10 or 12 in. above the head, and allowed to run through indiarubber tubing, to the end of which is fixed a flattened glass nozzle. The nozzle can be readily inserted below the upper and lower lids without touching the cornea. It is usually best to begin by everting the upper lid, and, after irrigating its tarsal surface, to insert the glass nozzle behind the upper margin of the tarsus, so as to get at the retro-tarsal fold. The following ointment, smeared into the eye morning and evening, will often very rapidly check a conjunctivitis :—

℞ Zinci oxidi	½ drm.
Ichthyol	1 gr.
Formaldehyde anhydr. (1 to 1000) .	5 minims.
Vaselini alb.	½ oz.

In cases due to the action of the Morax diplo-bacilli, this treat-

ment is practically always efficacious. In these cases the ointment may be used without the formaldehyde.

In the more severe and protracted cases, a daily direct application to the conjunctival surface, with a camel's-hair brush, of a strong antiseptic solution is useful. The most suitable are strong (fully saturated) chlorine water and nitrate of silver in a 2 per cent. solution. Though not always so readily got, the first is the better, and when painted over the palpebral conjunctiva causes no pain to speak of. Corrosive sublimate solutions should generally be avoided; they are more irritating and far less penetrating.

The margins of the lids should in all cases be kept smeared with some bland ointment. Fresh lard or fresh butter do very well. Vaseline is not always pure, and may cause irritation. Boracic ointment (boracic acid ½ drm., almond oil 20 mm., and spermaceti ointment ½ oz.) is probably the best.

The questions of light, and of the use of the eyes for reading, etc., remain to be considered. With all inflammations of the eye itself, as well as of the conjunctiva, there is more or less photophobia, or dread of light. It does not follow, however, that the light is actually hurtful. The actinic rays are known to cause irritation of the conjunctiva, which may, indeed, as in snow-blindness and electric-light ophthalmia, be so great as to lead to violent inflammation. On the other hand, the same rays have been shown to exert a powerful bactericidal effect. It is a very common treatment to keep patients suffering from conjunctivitis in a dark room. Often this is continued for weeks; and although the discomfort which light causes is thus avoided, there is little doubt that this treatment tends to prolong the inflammation rather than to cut it short. The patient, too, soon has his retina so adapted for the dark that even a little increase of light is painful, just as one may experience a degree of dazzling from the light of a match struck at night.

The light of an ordinary room in the daytime, when the sun's rays are not passing directly into it so as to be unpleasant to anyone else, has not any bad effect on a conjunctivitis. On the other hand, the use of dark glasses outside in bright weather is advisable. The open air, in the absence of rain or dust-clouds, is unquestionably good. This is often not properly realised; it is perhaps natural to suppose that there is an indication with a "cold in the eye" to remain indoors.

Reading or writing should not be allowed. In acute attacks it is seldom, however, that attempts at reading are persisted in. Why reading should be hurtful is not quite evident. It is

certain, however, that it adds greatly to the discomfort caused by the conjunctivitis, increasing at the same time the congestion. This discomfort, besides, does not pass off on continuing reading, as does the discomfort first felt in ordinary light on coming from a darkened room.

Whether as the result of inappropriate treatment or otherwise, inflammation of the conjunctiva, instead of entirely subsiding, may continue for an indefinite time as a chronic condition. *Chronic conjunctivitis* is met with in all degrees of severity, from what is little more than slight hyperæmia of the conjunctiva, to a greatly thickened, fleshy-looking, pus-secreting state of that membrane, with encrustation of the lid margin; often, too, owing to deeper infiltration, the palpebral fibres of the orbicularis fail to keep the lower lid properly in contact with the eye. The swollen conjunctiva thus becomes everted, and the excretion of tears is interfered with. The overflowing tears cause excoriation of the skin, and the ectropion once set up becomes more and more marked as time goes on. The everted conjunctiva, besides being thickened, is also hardened, as the result of constant exposure to the air, and may even be encrusted or covered by scales or scabs.

These very bad cases of chronic conjunctivitis are mostly met with in old people; they are not the cases one is most frequently called upon to treat.

In all cases in which conjunctivitis has become chronic, the first points to be ascertained, before any line of treatment is begun, are the nature of the external surroundings and of the treatment which has already been adopted. Where the patient is constantly subjected to smoky or hot and close atmosphere, or to any evident source of irritation, such conditions should, as far as possible, be removed. If he has been poulticing, or, what comes to the same thing, keeping moist applications to the eye, or tying it up and allowing the bandage to become moistened by tears, or if strong astringent lotions have been used, such treatment should at once be discontinued. It is generally well, too, to look to the state of the mucous membrane of the naso-pharynx, as a chronic catarrh in this situation is apt to keep up a conjunctivitis, even although it may not have been the principal cause in originating it. Still more important in this respect is the state of the tear sac. Inflammation of the mucous membrane lining the tear duct and sac is sometimes complicated by conjunctivitis, which may be set up by inoculation from this source. On the other hand, even severe purulent primary inflammation of the conjunctiva seldom, if ever, spreads to the

tear sac. A proper treatment of the inflammatory condition of the naso-pharynx is often useful, in addition to anything which may be undertaken for the more direct treatment of the conjunctivitis. But treatment of the sac for a coexisting blennorrhœa is an absolute necessity. Without an improvement in this situation no treatment of the conjunctivitis alone can be of much avail.

In the least severe cases of chronic conjunctivitis, in which there is little or no thickening of the conjunctiva, and not much increase in the secretions, it is not generally necessary, if the precautions referred to as to surroundings be taken, to do anything very active. It is mainly in respect to their origin, namely, a preceding acute attack, that they differ at all from cases of conjunctival congestion. They should therefore be treated much in the same way. Change of air, especially to some dry, high-lying inland place, may be tried, and any existing error of refraction should be corrected. In addition, a weak astringent may sometimes be useful, such as solutions of hazeline, tannic acid, myrrh, alum, or ichthyol.

The following are prescriptions which may be recommended for this purpose :—

℞ Hazelini . . . . . 4 oz.
Aquæ carui . . . . . 8 ,,

℞ Acidi tannici . . . . . 6–12 grs.
Sodæ biboratis . . . . . 3 drms.
Glycerini . . . . . 6 ,,
Aquam camphoræ ad . . . 12 oz.

℞ Tincturæ myrrhæ . . . . 2 drms.
Aquæ destillatæ . . . . 12 oz.

℞ Aluminis . . . . . 10–20 grs.
Aquæ rosæ . . . . . 12 oz.

℞ Ichthyoli . . . . . ½ drm.
Aquæ sambuci
Aquæ destillatæ, āā . . . . 6 oz.

In more severe cases, with thickening of the conjunctiva, swelling of the folds and deeper infiltration, as evidenced by slight ptosis, and with more or less distinct muco-purulent secretion, there is, I believe, nothing better than lead. A solution of the neutral subacetate of lead, in the strength of 10 grs. to the ounce of water, may be painted directly over the mucous surface of the everted lids once daily, and an irrigation of boracic acid made twice or thrice daily, or a wash of the same lead salt in weaker

solution ($\frac{1}{2}$–1 gr. to the ounce) may be used about three or four times in the twenty-four hours. In the worst cases, painting with strong chlorine water or a 2 per cent. solution of nitrate of silver once daily, is useful in addition to the lead wash. Where there is ectropion of the lower lid, the lower canaliculus should be slit with a Weber's knife. The scales must also be removed from the lid margin, and an ointment of iodoform and vaseline (1 to 7) smeared on the raw surface.

Owing to the frequency of folliculosis in young people, it often happens that the appearance of the conjunctiva presented in an ordinary muco-purulent inflammation is such as to suggest some different and specific type of conjunctivitis. The overgrowth of adenoid tissue may be so marked a feature, that the follicles appear as numerous papillæ in the swollen and congested membrane. When this is the case, it is not uncommon to hear the conjunctivitis spoken of as a *follicular conjunctivitis*. It is not improbable that the same irritation which causes the conjunctiva to inflame may give rise to some further follicular enlargement, but, as far as the inflammation goes, both in its causation and course, it is a simple conjunctivitis. The treatment should be in every way the same as that already described. Special care is, however, required in irrigating, as the presence of the many elevations makes it more difficult to thoroughly remove the secretions.

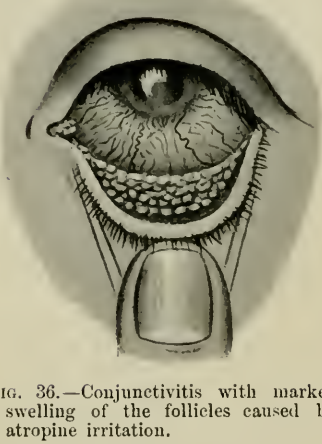


FIG. 36.—Conjunctivitis with marked swelling of the follicles caused by atropine irritation.

The treatment of cases of conjunctivitis with marginal ulceration of the cornea should be the same in most respects as that already described. Lead lotions must, however, be avoided, as they cause dense white deposits in the cicatrices, which remain after the ulcers have healed. Where the ulcers are superficial and small, a drop or two of a weak nitrate of silver solution (1 gr. to the ounce) may be dropped into the eye, after an irrigation with boracic lotion, once daily for three or four days. This often at once induces healing, even in cases where the ulcers have

continued in much the same state previously for a couple of weeks or longer. The ulcers often cause a good deal of pain. To allay this, cocaine may be used (a 2 to 5 per cent. solution of hydrochlorate); but it is not advisable to apply it very frequently —for instance, every half-hour, as is often done. Immediately before and after each irrigation is sufficient to give relief. It is a good plan, too, to drop a few drops into the eye the last thing at night, as the local anæsthesia thus caused often allows the patient to fall asleep, which the pain otherwise prevents. Eserine drops are often recommended for the treatment of catarrhal as well as for other forms of corneal ulcer. I have never been able to satisfy myself that they are of any use at all for this purpose; and as they are sometimes actually hurtful, they should not be used. Dark glasses are particularly indicated in all cases of conjunctivitis with marginal corneal ulceration.

Deeper and more rapidly extending marginal ulcers should be brushed once or twice with chlorine water (full strength), or, if this is not available, with a 2 per cent. solution of nitrate of silver. The brushing, to be effectual, should be done with some force, the camel's hair being dabbed on to the ulcers several times, so as to bring the antiseptic properly in contact with all parts of their surface. By using cocaine this can be done without causing any pain to speak of. Afterwards, dusting with finely-powdered iodoform is useful after each irrigation. The application of iodoform in powder is preferable to its use either in ointment or in gelatin discs, the latter of which dissolve in a few minutes and leave only a comparatively small quantity of the iodoform *in situ*. When deeper marginal corneal ulcerations exist, in the absence of much conjunctival secretion it is sometimes a good plan, if they do not tend to heal, to cover them with a flap of conjunctiva. This is done by undermining the surrounding conjunctiva with scissors and stitching it forwards.

Spring catarrh.—A peculiar variety of recurrent chronic conjunctivitis has received the name of spring catarrh. This is a rather rare affection, met with in young individuals, and characterised by an injection and swelling, limited to the circumcorneal portion of the ocular conjunctiva. The elevations which are met with in this situation, and which either extend all round the cornea, or are limited to some portions of its margin, are solid greyish milky-looking masses, which show no tendency to ulcerate. In this respect, as well as on account of their solidity, they are readily distinguished from phlyctenules, which they at first sight sometimes resemble. Associated with this affection there is, also, a more or less characteristic milky-white coloration of the

conjunctiva as a whole. In some cases the condition is accompanied by some increase in the secretions. Slight infiltration of the corneal margin may occur—never, however, extending far in; and, beyond a sometimes high degree of photophobia, the affection does not give rise to any symptoms of consequence. Not unfrequently flattened masses of cartilaginous-looking granulation tissue make their appearance on the surface of the tarsal portion of the conjunctiva of the upper lid. These may attain an enormous size, and such cases are liable to be mistaken for trachoma. The inflammation has, more than other forms of conjunctivitis, a tendency to recur every spring, and to continue, when once set up, for several months. In many cases the improvement which takes place at the beginning of the winter appears not to go on to complete recovery, so that the condition in spring may be looked upon more as an exacerbation than as a true recurrence. Spring catarrh is in reality a hyperplasia of the epithelium alone; there is no deep infiltration.

Treatment.—Astringent lotions should be avoided. If there is much photophobia, dark glasses may be used. Excision of the granulations when they are massive, or, still better, burning them down carefully with the thermo-cautery, is the best treatment. No cicatrix need be left if this is properly done.

Purulent conjunctivitis.—Although an acute attack of simple conjunctivitis is often accompanied by considerable purulent discharge, it is nevertheless important, from a clinical point of view, to make a distinction between this and the more characteristically purulent forms of inflammation, namely, *gonorrhœal conjunctivitis* and the conjunctivitis of new-born infants, *ophthalmia neonatorum.*

Gonorrhœal conjunctivitis, or gonorrhœal ophthalmia, is one of the most serious inflammations met with in the eye. It is set up usually by the direct transference of pus from a gonorrhœa into the conjunctival sac. Such pus is now known to acquire its virulence from the presence of *gonococci.* The first symptoms begin several hours, or it may be as late as a day or two, after inoculation. The appearance during the first day may be such as to suggest merely an acute attack of simple conjunctivitis. More frequently the rapidity with which the symptoms set in, and especially the early appearance of more or less chemosis, excites suspicion, and leads to the detection of the source of inflammation. The pus finds its way to the eye from a urethral or vaginal gonorrhœa, or from a similar inflammation in some other eye, so that the inoculation may either be from the individual himself, or from some one else whose towel has

been soiled by the discharge, and used subsequently by the patient. The great importance of warning patients suffering from gonorrhœa of the danger to their own eyes, and those of others living in the same room, of using towels, sponges, etc., in common, and of the consequent necessity of absolute cleanliness, cannot be exaggerated.

Considerable differences exist in the length of time before the inflammation reaches its full height and leads to a copious purulent discharge. What is usually distinguished as the first stage, in which there is only a watery and slightly mucoid discharge, often considerable in amount, may last a couple of days or more, or may rapidly pass on to chemosis, due to a fibrino-plastic exudation beneath the conjunctiva, and to swelling and redness of the lid. The second stage, which is characterised by the purulent discharge in addition to the chemosis and swelling of the lid, may then be reached on the second day after the first symptoms have made their appearance, or may be delayed, and this is more common, till the third or fourth day, or even later.

The difference in the rapidity of development has been shown to stand in close connection with the amount of active inoculating matter which enters the eye. Small amount, dilution, and desiccation all retard the onset as well as the rapidity with which the abnormal changes succeed each other. Yet the resulting inflammation may be, and most frequently is, just as violent as that which results from inoculation with a more copious, and, at the time, a more virulent secretion. This fact is of practical importance, in so far as it indicates the possibility of checking the disease in some cases by timely antiseptic measures.

Besides the appearances described as characterising the first stage of gonorrhœal ophthalmia, more or less pronounced subjective symptoms—pain, burning and neuralgic in character, photophobia, and lachrymation—are constant, and increase as the tenseness of the swelling of the conjunctiva and lid becomes greater and greater. The swelling of the upper lid generally reaches such a degree as to cause it to hang down over the lower lid, and to assume a red glossy appearance on its surface. It is then perfectly impossible for the patient to open his eye, or even for the lid to be raised to any extent with the finger. The full height of the inflammation generally continues for from one to three days, after which the skin of the lids regains some of its natural wrinkling, and the circulation in the conjunctiva becomes freer. The discharge continues as copious

as before, but less flocculent, and the conjunctiva becomes redder and softer.

The hardness, caused by the serous and often fibrino-plastic subconjunctival effusion during the course of the inflammation, is a source of danger to the cornea, whose nutrition, derived as it is from the surrounding vessels, is thereby more or less interfered with. It is not uncommon to find, therefore, a steaminess or loss of transparency of the cornea, which at the time of examination may or may not be associated with ulceration. This ulceration is often near the margin of the cornea, and is then hidden by overlapping portions of chemosed conjunctiva; it has a tendency to extend, not only in depth, but also circumferentially. When extension takes place in the latter direction, the result is apt to be a necrosis of the whole central portion of the cornea, and a consequent hopeless destruction of vision. A complication with corneal ulceration may also be met with at a later stage of the disease, during the period of retrogression. The ulcers then formed have not unlikely quite a different etiology and are more amenable to treatment, and consequently less likely to lead to total destruction of the cornea. They are usually due to the inoculation of the corneal tissue with the pus from the conjunctiva. As long as the conjunctival discharge continues, there is the possibility of a complication of this nature, although the danger diminishes every day. On this account it is important to avoid any rough handling during the treatment of the lids, as any abrasion of the cornea very much increases the risk of inoculation. Most likely corneal affections met with at any stage of the conjunctival inflammation are, properly speaking, infective. While, however, the later ones are only liable to make their appearance where the cornea is abraded, the more serious early ulcerations may be accounted for by supposing that there is first a maceration of and interference with the vitality of the superficial layers, and subsequently, inoculation.

In acute cases, complete recovery of the conjunctival inflammation, and a return to the normal condition without any loss of substance, takes place in from three to six weeks. Some cases gradually lapse into a chronic state. In these cases the conjunctiva often remains enormously swollen for months, the tarsal portion assuming a thick and more or less uniform velvety appearance, while the retrotarsal folds present large fleshy elevations and furrows, which protrude into prominences when the lids are everted. Not unfrequently this leads to *ectropion*. The lower lid is more often everted, on account of the smaller

size of the tarsus, and the thickening of the skin produced by excoriation of the overflowing tears and secretion. Occasionally, however, the upper lid is everted as well, the everted portion being often hardened and encrusted if not properly attended to.

While in all conditions the cornea is liable to ulceration from inoculation, the more serious, and, properly speaking, necrotic form is less liable to make its appearance, or at all events to show the same tendency to circumferential extension in cases where a previous abnormal vascularity has existed. This circumstance is taken advantage of in the treatment by inoculation of cases of dense superficial vascular keratitis or pannus. (See p. 152.)

Having regard to the grave consequences to the cornea which a purulent conjunctivitis may entail, the *treatment* has to be considered not only from the point of view of what is best for the infected eye, but also with regard to prophylaxis in the case of the other eye. Indeed, the first thing which should always be done, whenever there is cause to diagnose a gonorrhœal or other purulent conjunctivitis of the one eye, is to actively disinfect the other, and then secure it against the risk of subsequent infection —a risk which, it must be remembered, exists so long as the purulent discharge continues. The disinfecting of the sound eye is of course undertaken on the supposition that it may possibly have been recently inoculated, and may be done in the following way: After dropping a little cocaine solution into the conjunctival sac, the lids are everted, and the mucous surfaces, including as far as possible the folds, painted over with chlorine water. The lid margins are then rubbed freely with little pledgets of absorbent cotton-wool moistened in the same antiseptic. This is followed by a free irrigation of the whole conjunctival sac, with not less than a pint of a 2 per cent. boracic acid solution. A little iodoform or boracic ointment is lastly rubbed along the lid margins and the occlusion dressing applied.

It is advisable to adopt some arrangement whereby sufficient protection is provided against inoculation, while at the same time the good eye is not altogether thrown out of use. The simplest and most readily prepared contrivance for this purpose is what is known as Buller's shield. This consists of an ordinary watch-glass fixed in an aperture between two pieces of adhesive plaster so that three margins of its under surface can be readily fixed along the forehead, down the side of the cheek, and along the nose. The lower edge is not plastered to the face. This allows the air to get in behind the shield and prevents dimming the glass.

In applying the shield the watch-glass should be secured in a suitable position in front of the eye, and particular care should be taken that the margin along the nose adheres tightly. An extra strip of plaster may with advantage be fixed over this margin. The advantage of Buller's shield over a regular occlusion bandage is not confined to the relative comfort which the patient obtains. An additional advantage is, that it does not as

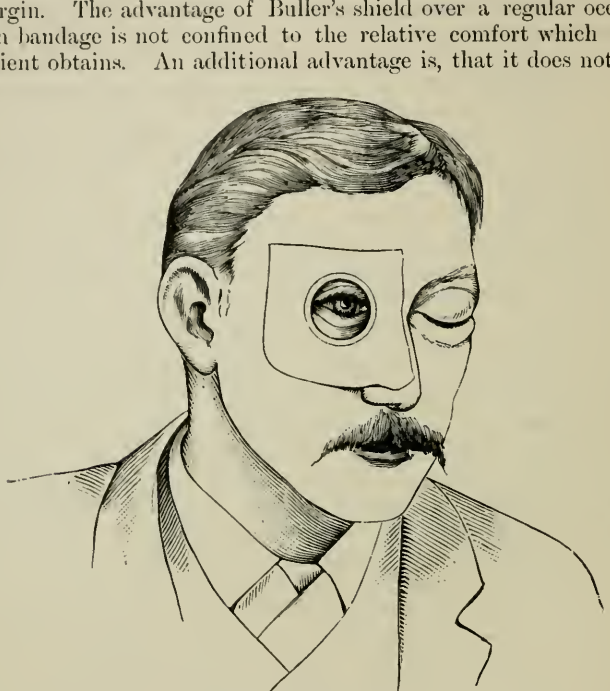


FIG. 37.—Buller's shield.

a rule require to be changed, as it admits of a ready inspection of the eye by the surgeon.

In the treatment of the inflamed eye everything must be done which is calculated to prevent the cornea becoming involved. It is well to recognise that the main, if not the only, cause of an accompanying corneal ulceration is an inoculation with the specific discharge in places from which the protecting epithelial surface has been removed. The denuded cornea is certainly easily inoculated. Possibly inoculation may take place even when the epithelial covering remains intact. It certainly does not do so so

readily, and therefore from a clinical point of view it is well to keep before one the desirability of providing as far as possible for the protection of the epithelium. Careful handling is therefore a most necessary precaution. Removal of epithelium is too often caused by forcible opening of the swollen lids. Owing to the pain and swelling of the lids, it is no doubt often difficult to get a proper view of the eye without using some force. Perhaps the best plan is to drop a few drops of a solution of cocaine (2 to 5 per cent.) into the eye, and then separate the lids by the finger tips applied to their margins, taking care not to allow the nails to scrape on the cornea. Indeed, the use of the cocaine should be as much to facilitate gentle handling as to diminish the pain which an examination causes the patient. This is often forgotten, yet it is of great importance. Cocaine should only be used during any manipulations which the treatment renders necessary, not at other times. Elevators or a speculum should in general be avoided, and when introduced, and whilst *in situ*, must be kept held away from the cornea, so that the epithelium may not be injured in any movement of the eye. Strong caustic solutions are also liable to injure the corneal epithelium when applied to the conjunctiva. Those most commonly in use are solutions of nitrate of silver and corrosive sublimate. The former should not be used on this account stronger than 2 per cent., or 10 grs. to the oz., and the latter not more than 0·0002 per cent., or about 1 gr. to 10 oz. But it is better to avoid these solutions altogether.

Inoculation, the result of corneal abrasion, may occur at any part of the cornea. The treatment is very often to blame when an ulcer occurs in a central portion of the cornea, as it has then certainly been preceded by an abrasion which has been more or less preventible. It is otherwise with the more frequent marginal ulceration, the existence of which is often first evidenced by a cloudy opacity passing into the cornea in some particular direction. The ulcer itself at its beginning is not unfrequently covered by the overlapping chemosed conjunctiva of the globe. Such ulcers originate from inoculation by discharge which is pent up between the chemosed conjunctiva and the corneal margin. Whether the discharge in this position leads to a localised loss of corneal epithelium from maceration, and only then effects an inoculation, or whether the more prolonged contact of the virulent matter overcomes the resistance of the epithelium, is a point of no practical importance. The practical consideration is really the necessity for preventing any stagnation of the secretion in this situation. There are two ways in

which this indication may be complied with—first, by irrigation, and secondly, by excision of the conjunctiva immediately surrounding the cornea. Irrigation with boracic lotion, as already described, is sufficient where the chemosis is slight. When the conjunctiva overlaps the cornea, however, as a tense and swollen membrane, it is undoubtedly safer not to rely upon irrigation alone, but to freely remove with a pair of scissors the overlapping zone, so that the corneal margin in its entirety is exposed and readily kept clean. This is a much more efficient treatment than that often recommended, of making radial incisions in the chemotic conjunctiva. Such incisions, by reducing the swelling, diminish the tenseness of the overlapping, and therefore to some extent fulfil the same indication; but it is better, when interfering at all surgically, to perform a regular peritomy. In addition to frequent irrigations, the conjunctiva covering the lids may be painted twice daily with chlorine water. The patient should be allowed to be out in the open air and sunlight as much as possible. A little boracic or iodoform ointment may be smeared along the edges of the lids at night to prevent retention of the secretions.

When the cornea does suffer, efforts to check the progress of the ulceration are mostly unsuccessful. A touch on the surface of the ulcer with a camel's-hair brush dipped in chlorine water, followed by dusting on of finely powdered iodoform, may be tried.

Ophthalmia neonatorum is practically the same disease as that just described; that is to say, it is due to an inoculation with a specific virus. The virus is probably not always the same, or at all events, what may be specifically the same, has suffered some modification, as there are greater differences met with in the intensity of this form of inflammation than can well be accounted for by merely individual receptive differences on the part of the patients.

Inoculation of the eyes of infants takes place in two ways—either directly from the maternal passages during birth, or afterwards by the use of soiled linen, sponges, etc. In the first case the inflammation usually begins on the third day, although it may be delayed two or three days longer, and both eyes, as a rule, are affected. In the second case the first appearances are often later in presenting themselves, and not so frequently in both eyes simultaneously. Purulent inflammation beginning after the first week is almost certainly due to some extraneous source of inoculation. The liability to purulent conjunctivitis in the new-born infant is greater the more prolonged the birth.

Ophthalmia neonatorum is not by any means as a rule so severe an inflammation as purulent conjunctivitis in the adult. In the great majority of cases it is mainly the palpebral conjunctiva which is affected, so that the cornea does not run the same danger. The corneal complications which do arise are mostly the result of unskilful handling and want of cleanliness; that is to say, they are of the directly infected type, and can often be arrested by proper treatment. It is seldom that one feels so helpless with respect to them as is the case with the early ulcerations in gonorrhœal ophthalmia.

Nevertheless, ophthalmia neonatorum is an extremely dangerous inflammation, and one which too often results in more or less complete destruction of sight.

The *treatment* has to be considered both from the point of view of prophylaxis as well as from that of cure (to use a popular expression), when the inflammation has been established. The prophylactic treatment has been followed by the most conspicuous success, so that from this cause alone a very great diminution in the number of cases of early blindness has resulted. It is, consequently, unmistakably the duty of every medical practitioner who is in the habit of attending confinements, as well as of midwives, not to neglect such prophylaxis in any case where there appears to be the least necessity for it.

Inoculation can practically, almost always, be counteracted by the following treatment:—

As soon as the child is born, the eyes are wiped carefully with a little cotton-wool which has been dipped in freshly boiled water at a temperature of 100° F. Care is then taken that the water used for the bath does not come in contact with the eyes. Immediately after the general cleansing, the eyes should be well washed with the boiled water trickled into them from absorbent wool as the lids are held apart. They are then thoroughly dried, and a drop or two of a 2 per cent. solution of nitrate of silver dropped into each conjunctival sac. This is the method of Credé. It is certainly at once the simplest and the most efficient prophylactic treatment.

It is, no doubt, also a good plan to make use of antiseptic douching of the vagina before birth. This may prevent an inoculation taking place at all, but does not do away with the necessity for the treatment of the child's eyes in the way just described.

Inoculation may take place also before birth. It is extremely rare to meet with an already developed purulent conjunctivitis at birth, and in such cases there can be no question of prophy-

laxis. On the other hand, the mother or nurse should be warned of the possibility of late infection through want of cleanliness.

The treatment to be adopted in ophthalmia neonatorum should be much on the same lines as that for purulent conjunctivitis in adults. An occlusion bandage is unnecessary for the one eye, as even in the comparatively few cases in which only the one eye is affected (mostly cases of inoculation after birth) it is not easy to keep it properly applied. Incision or circumcision of the ocular conjunctiva is also inadvisable. It is rare that the chemosis is as excessive as in the adult, and besides, it is well to avoid loss of blood in infants. Irrigation should be made frequently and carefully, always bearing in mind the risk of any corneal abrasion. The painting of the everted lids with chlorine water may be done twice a day; and later on, when the lids are lax and the swelling has subsided but the secretion from the conjunctiva is nevertheless copious, a daily brushing with a 2 per cent. solution of nitrate of silver may be substituted for the chlorine water.

It should be remembered that even when the cornea becomes implicated the prognosis is relatively much more favourable than in adults. The tissue changes are more active and rapid, so that the cicatricial tissue may become in the course of time replaced by clear corneal connective tissue. When no perforation has taken place, the prognosis is good. With perforation, on the other hand, much will depend upon its extent and site, as well as upon whether or not it is accompanied or followed by alterations in the shape of the cornea. When there is only a partial staphyloma it is well to perform iridectomy early.

In a good many cases of ophthalmia neonatorum the conjunctival surfaces of the lids are found to be covered by a membrane. This form of *membranous conjunctivitis* must be distinguished from diphtheritic conjunctivitis. The membrane is easily detached, and although there is a tendency towards bleeding from the conjunctiva when it is rubbed off, it can readily be seen not to be due to any intimate adherence between the membrane and the conjunctiva, such as characterises diphtheritic inflammation. The abundance of the purulent secretion, as well as the absence of the livid grey coloration and marked constitutional disturbance, also distinguish this form from the much more uncommon diphtheritic conjunctivitis. Coagulation of the secretion from an inflamed conjunctiva seems to take place in a proportion of cases, resulting from all, or almost all, causes of irritation. Thus the irritant may be a foreign body lodged in the conjunctival folds, or a chemical irritant, or an eczema, or some of the cocci

and bacilli which are known to lead to conjunctivitis. Further, the membrane may vary greatly in its character, from quite a thin pellucid pellicle, which can be floated off the conjunctival surface by a gentle stream of liquid, to a pretty dense and fairly adherent coagulation, which to separate from the conjunctiva requires some degree of rubbing or traction, and which when removed leaves a raw and bleeding surface.

In the *treatment* of membranous cases, of whatever causation, the application of caustic solutions should be avoided.

Phlyctenular conjunctivitis.—A very common variety of conjunctival inflammation is one in which the congestion is less diffused. It is mainly the ocular conjunctiva which is

FIG. 38.—Phlyctenular conjunctivitis.

affected, and that in more or less definitely circumscribed areas. These areas of congestion may be at any part. They are met with in single patches, or distributed more or less all over the white of the eye. Very often the mid-point of a congested patch lies on or near the corneo-scleral margin. The main characteristic, however, of this variety of conjunctivitis, and that which gives to it the name "phlyctenular," is the presence of little blebs on the surface of the congested portions of conjunctiva. These blebs vary considerably in size. Many of them are so small as to be only recognisable on close inspection. Very commonly they have a diameter of 1 mm. Occasionally they are met with three or four times this size. The larger ones

are usually seen as collapsed bullæ, sometimes as regular pustules when their liquid contents have become purulent. At a later stage, when the epithelial covering has been shed, they are converted into small superficial ulcers, and eventually heal without leaving any visible changes.

Two points in connection with phlyctenular conjunctivitis call for consideration as matters of practical importance. In the first place, the condition is always indicative of some constitutional delicacy. Again, more or less serious complications on the part of the cornea are to be feared. Corneal complications, however, are in this case of a different nature from those which have been referred to as existing in other forms of conjunctivitis.

FIG. 39.—Pustular conjunctivitis.

They are apparently not auto-infections caused by the specific action of the secretion from the inflamed conjunctiva. Indeed, altogether in this affection, when uncomplicated, the conjunctival secretions are not markedly altered, although no doubt there is frequently an increase in the watery constituent—a more or less pronounced degree of lachrymation.

Clinically, this difference in the connection existing between the conjunctival and corneal inflammation in phlyctenular, as compared with other varieties of conjunctivitis, is important. It is most probable, indeed, that phlyctenular conjunctival and corneal inflammation has a microbic origin, just as other forms of conjunctivitis have. Certain investigations seem to show that such is the case. Yet even if it be so, there is here not

so much a question of the risk of contagion of a healthy cornea from contact with an altered conjunctival secretion, as of the existence of a suitable soil for the development of more or less characteristic corneal changes from the same cause as the specific conjunctivitis. The indications for treatment are therefore of a different nature.

The corneal changes so often occurring along with phlyctenular conjunctivitis are essentially superficial. They are met with as single or multiple superficial infiltrations of varying size. These infiltrations are often, though not invariably, vascularised. They leave corresponding opacities, so-called *nebulæ*, only the most superficial and least extensive of which may subsequently clear up. These nebulæ, according to their size and density and site, interfere with vision by causing irregularities of the surface of the cornea, and by scattering, instead of properly refracting, the light-rays which pass through them into the eye.

Phlyctenular conjunctivitis and keratitis are mostly met with in children, and have a tendency to recur at intervals for a number of years. In many cases there is considerable, often very great, dread of light—photophobia. This leads to a more or less convulsive closing of the lids,—blepharospasm,—a condition which not only complicates, but actually aggravates and prolongs the local inflammation. Sometimes, indeed, though rarely, the strong pressure of the spasmodically closed lids on the eyes produces great lowering of the intra-ocular tension, and may lead to serious interference with nutrition.

When phlyctenular conjunctivitis, with or without its attendant superficial keratitis, is met with in adults, it is mostly in individuals who have suffered from the same form of inflammation in childhood. It comparatively rarely occurs for the first time after puberty.

Treatment must be both local and general. The local treatment should not be confined to the use of measures which are calculated to have a direct influence on the conjunctival and corneal inflammation. It is often a matter of quite as great importance to give special attention to the treatment of such an aggravating complication as blepharospasm. In old-standing cases, too, it may be necessary to do something to relieve the lid pressure on the eyes which results from narrowing of the lid apertures. Often, again, there is an associated blepharitis, which calls for treatment at the same time. Further, the condition of refraction should always be examined into, and if necessary corrected, in the case of patients who, after recovery from an attack, are old enough to be able to read.

With regard to local applications, it is important to remember that astringent lotions of all kinds are not generally well tolerated. The eyes should, however, be kept clean by being bathed several times daily with boiled water, or boracic acid lotion. Tying-up of the eye, so often practised in these cases, is decidedly hurtful. It not only increases the tendency to blepharospasm, but very often virtually amounts to poulticing, as the bandage soon gets saturated by the tears, which are always more copious than under normal conditions.

Many substances have been used in the form of ointment applied directly to the eye. The most useful, however, is the yellow oxide of mercury. This substance has the properties of a stimulant and antiseptic combined, and in the class of cases under consideration is, more than any other, practically a specific. Other preparations of mercury are no doubt also useful. The yellow oxide, however, is the only one that may reasonably be regarded as a specific in phlyctenular inflammation. It is generally used in the form of ointment, in the strength of 8 to 20 grs. to the ounce. As such, it goes by the name of Pagenstecher's ointment. The yellow oxide may be mixed with different bland ointments. The following preparation can be recommended :—

℞	Hydrargyri oxidi flavi	4 grs.
	Olei amygdallaris	20 minims.
	Ung. cetacei (sine benzoino) . . .	½ oz.

This should be applied once in the twenty-four hours, and preferably at night. A piece about the size of a split pea is inserted between the lids at the outer canthus. The lids are then rubbed gently over the eye, so as to combine a kind of local massage with the spreading of the ointment. This massage seems to be of some importance in increasing the efficacy of the application. In order to be able to do it properly, it is often advisable to drop a drop or two of a 2 per cent. solution of cocaine into the eye a few minutes before using the ointment. Any blunt, smooth, clean instrument does for introducing the yellow oxide ointment—a glass rod is perhaps the best. The lids are separated with the forefinger and thumb of the left hand, while the end of the rod, with the ointment adhering, is placed between them. Then with the same fingers the lids are pressed together, and made to wipe off the ointment as the rod is withdrawn.

Before any of the Pagenstecher ointment is used, it is important to see that it has been properly prepared. A little,

removed on a glass rod, should for this purpose be examined with an ordinary magnifying glass. If any little gritty particles are then seen, the ointment is unsuitable, and will cause too much irritation. This precaution is often neglected, and the irritation produced by wrongly-prepared yellow oxide ointment is one of the reasons why many ophthalmic surgeons, and without doubt to the disadvantage of their patients, do not use the ointment at all. Another point which is often forgotten is that, valuable as the yellow oxide ointment is in the real phlyctenular type of superficial corneal inflammation, it is useless or hurtful in many other inflammations of the cornea. Even in the phlyctenular cases it is not as a rule so well tolerated by adults as by children. Consequently it is well to begin by using it not so strong, and afterwards increase the strength if it causes no marked irritation. As a general rule the hyperæmia, and accompanying sensation of pain or burning in the eye, does not last longer than from five to fifteen minutes after the use of the ointment. In any case in which they are more prolonged, the ointment should be considered irritating, and be weakened or discontinued.

The yellow oxide application should be made so soon as any characteristic phlyctenules appear on the conjunctiva, and should be continued for a month, or longer, after they have completely disappeared. There is little doubt that, by doing so, relapses, and especially corneal complications, can often be prevented. As recurrences are apt to take place in children, who are especially liable to this form of inflammation, the parents should be instructed to have recourse to the treatment as soon as the phlyctenules show themselves. The ointment should of course be freshly and properly prepared each time.

Attention should also be directed in all chronic cases to the condition of the naso-pharynx, which will often be found to call for treatment. Often such treatment will have a more or less marked influence on the conjunctival affection.

Blepharospasm, which originates reflexly as the result of an irritation of the superficial sensory nerve-twigs of the cornea, and in consequence of the curious photophobia which this irritation produces, often becomes so intense as to call for special treatment. The blepharospasm is most violent in children. It stands in no evident relation to the severity of the corneal mischief, though it is no doubt frequently aggravated by injudicious treatment. It is, for instance, encouraged rather than relieved by keeping the children in the dark, as is so often done, and still more so by bandaging the eyes. It is also bad to

allow the little patients to be constantly holding in front of, and actually pressing into, their eyes a handkerchief or cloth, which soon becomes moistened by tears, and which, in the case of ill-tended children, usually is allowed to become dirty as well. Often children suffering in this way are over-coddled and spoilt by too much sympathy, and by being carried about instead of being allowed to walk. All this favours the convulsive closure of the eyes. After some time, too, the difficulty of opening the eyes is increased by excoriations of the skin which the tears cause, principally at the outer canthus.

The first thing to do is to try to break the bad habit which such treatment has fostered. For this purpose cocaine in a 2 per cent. solution may be freely dropped into the eyes several times a day. The patients may be allowed to wear a brown paper shade covering both eyes. They should, however, be prevented as far as possible from constantly mopping or holding any cloth in front of their eyes. They should not be carried, but allowed to find their own way about, both in the house and outside, where, except in very bad weather, they should be kept as much as possible. Often, if these different points are properly attended to, the photophobia may become less pronounced, and the blepharospasm checked.

In a number of cases something more, however, is required to get rid of the blepharospasm. In young children up to 4 years of age a good plan is to plunge the head into cold water, holding it there until the child begins to gasp for breath. This causes a shock which makes the child open its eyes, and when it has done so once or twice it afterwards becomes easier under natural conditions. In older children, forcible opening of the eyes, and dilatation of the lid aperture, is useful. This is best done by means of elevators introduced below the upper and lower lids, and pulled apart with some force. Cocaine may be first dropped into the eyes, and an existing excoriation of the skin at the outer canthus may be lightly touched with a piece of caustic. The forcible dilatation may sometimes be repeated several times, at a day or two's interval, with advantage. This is, however, seldom necessary. In bad cases, in which no improvement follows one dilatation, it is better to sever the fibres of the orbicularis at the outer canthus with a pair of strong, straight, blunt-pointed scissors. To do this, one blade of the scissors is passed into the conjunctival sac, and pushed as far outwards in a line with the lid aperture as it will go. The scissors are then firmly closed, so as to cut through all the tissues from skin to conjunctiva. The bleeding is usually pretty free, but is readily

stopped by pressure or torsion. The cuts are then allowed to heal without being stitched.

In cases in which there have been repeated attacks of phlyctenular inflammation, and the lid apertures have become permanently contracted, a very great improvement may be got by the operation of *canthoplasty*. The first step in this operation is the same as that just described for cutting across the orbicularis fibres. The wound is, however, not allowed to

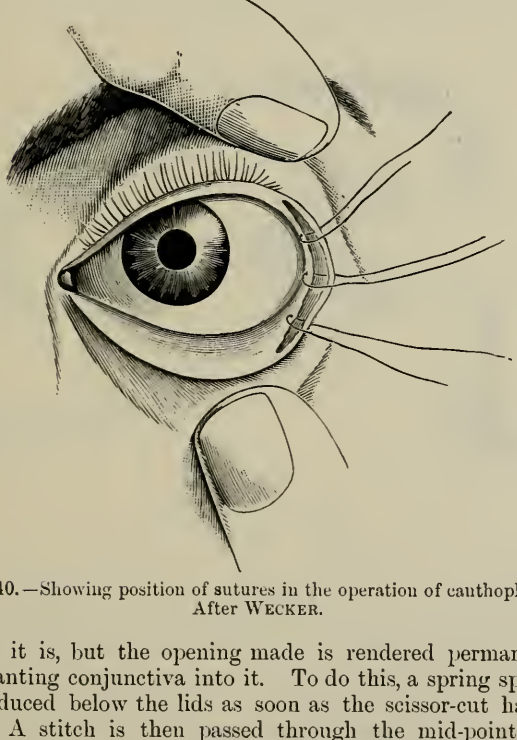


FIG. 40.—Showing position of sutures in the operation of canthoplasty. After WECKER.

heal as it is, but the opening made is rendered permanent by transplanting conjunctiva into it. To do this, a spring speculum is introduced below the lids as soon as the scissor-cut has been made. A stitch is then passed through the mid-point of the severed conjunctiva, and carried out through the skin at the apex of the wound. On knotting this, the conjunctiva is forcibly drawn to the outer end of the incision. Two other stitches should then be applied, one above and one below, by which the conjunctiva is further drawn to the upper and lower edges of

the skin wound. Care must be taken that in all these stitches the raw surface of the conjunctiva is brought into contact with the raw surface of the skin, and that no fold of conjunctiva is caught in the suture. No dressing need be applied, and the stitches may be removed after three or four days.

Where a similar operation is indicated in cases where the conjunctiva has undergone degenerative changes, and can therefore not be transplanted in this manner, the aperture may be kept open by transplanting skin. An operation of this kind, which gives very good results, was first recommended by Kuhnt. A flap of skin, the shape of which is shown in Fig. 41, is cut from the upper or lower lid. The base of this flap, one quarter

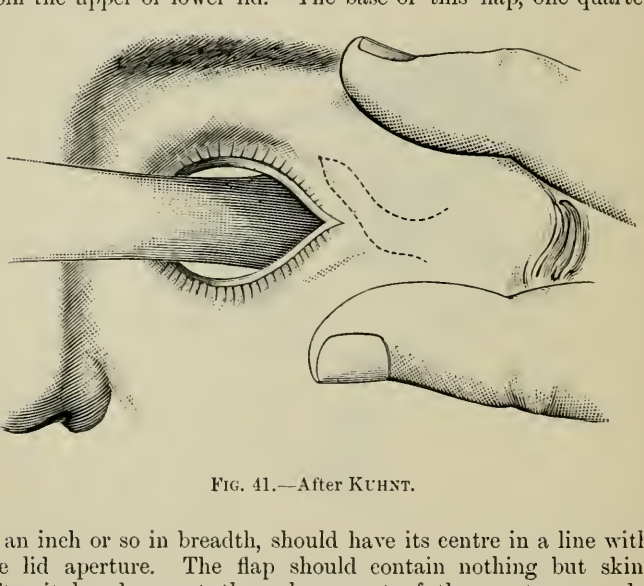


Fig. 41.—After Kuhnt.

of an inch or so in breadth, should have its centre in a line with the lid aperture. The flap should contain nothing but skin. After it has been cut, the enlargement of the aperture may be made with the scissors in the manner just described. The conjunctiva is then undermined for a short distance. After this has been done, the skin flap is turned into the wound, and its end inserted below the conjunctiva, while the edges of the skin, from which the flap has been cut, are brought together by sutures. An antiseptic dressing is then applied, and left unchanged for two or three days. It is best not to put any stitches into the skin flap, but merely push it under the conjunctiva for some distance, to leave room for shrinkage. It

gradually assumes more and more of the character of mucous membrane.

With regard to the *general treatment* of patients suffering from phlyctenular conjunctivitis and keratitis, it is important to remember that the condition always indicates some lowered state of vitality. In a large proportion of cases there is found to be a more or less pronounced strumous diathesis. The cervical glands, for instance, are very frequently enlarged. Apart from such diathesis, and still more where it does exist, the first attack of the characteristic inflammation is often seen to follow recovery from measles or whooping-cough.

Attention must in all cases be given to diet, which should be generous. In poor, ill-fed, and ill-tended children, in whom phlyctenular inflammation is most prevalent, great improvement often at once follows their admission to hospital, and that altogether independent of any special treatment—merely as the result of better feeding. In all cases cod-liver oil, alone or combined with malt in some form, is of great use. It is, in point of fact, to many both food and medicine. Syrup of the iodide of iron may also be given with advantage. Proper regard to the condition of the skin is very essential. A daily bath should be given, and clean underclothing worn. Children suffering from phlyctenular inflammation are, as a rule, benefited by being sent to high-lying places inland. Their state is often aggravated, on the other hand, by residence near the sea, though this is far from being invariably the case.

Not only on account of the eye trouble itself, but also owing to the local manifestations indicating a constitutional weakness, it is advisable to discourage schooling. The importance of this is apt to be overlooked, especially amongst the working classes. There is not only the dread of interference on the part of the local School Board with which one may have to contend in trying to get parents to keep their children from school for a sufficiently long time, there is, besides, the real inconvenience which keeping an older child at home often entails on mothers who have younger ones to attend to in addition to their household work. Often, however, when these difficulties are particularly pressing in the case of poor town children, there may be found relatives in the country to whom they can be sent, or, failing this, it may be possible to gain admission for them into some suitable Convalescent Home.

Inasmuch as phlyctenular inflammation is one of the most fruitful sources of more or less serious permanent defect of sight, it is of the utmost importance that careful attention

should everywhere be given to its treatment, both local and general.

Diphtheritic conjunctivitis may exist alone, or along with diphtheria of the throat. In the latter case it would appear that the conjunctival inflammation is generally the first to make its appearance. This affection is very rare in Scotland, though met with pretty frequently in some countries, especially North Germany. In London, too, it is not infrequent. Stephenson, for instance, has found it in fully 1 per cent. of the cases attending the out-patient departments of the London Children's Hospitals.

The inflammation begins with hyperæmia and lachrymation, just as in simple catarrh, and in the severer cases rapidly proceeds to great swelling of the lids and chemosis, as in purulent conjunctivitis. The infiltration of the lids leads to greater stiffness and pain than in purulent conjunctivitis. A greyish-yellow membrane is not long in making its appearance on the palpebral conjunctiva, and may also involve the ocular conjunctiva. The false membrane may cover only a portion of the surface of the conjunctiva, or may be found in patches over the surface. These patches sometimes become more confluent, and such cases are the most severe. The membrane cannot be completely removed without leaving a raw bleeding surface, which itself has not the natural healthy appearance, but presents that of a fibrinously infiltrated tissue. The discharge, to begin with, is less in quantity and much thinner than in purulent conjunctivitis, though it often afterwards becomes more copious and purulent.

There is danger for the cornea throughout, but the risk is greatest during the first few days. The cornea may be lost, as the result of a kind of necrotic and diphtheritic process combined. Ulcerations occurring at later stages are not so likely to lead to total destruction of the cornea. They are more superficial and more allied to phlyctenular or eczematous ulcers. Constitutional symptoms, fever, and pronounced lassitude are met with in a much more marked degree than in other forms of conjunctivitis, but the affection rarely proves fatal unless there is at the same time a throat complication. Diphtheritic conjunctivitis appears to be most common in young children. Only about 10 per cent. of the cases are met with after the age of four years. The sexes are equally affected.

In all cases of true conjunctival diphtheria the exciting cause is the Klebs-Löffler bacillus. This microbe is capable of setting up a conjunctivitis which in different cases exhibits all degrees

of severity, from what is only a trifling inflammation, barely distinguishable, if at all, from the milder forms of catarrhal conjunctivitis, to the characteristic severe disease which leads to destruction of the conjunctiva and subsequent cicatrisation. The reasons for this difference in severity are probably various. There may be differences in susceptibility, in the virulence of the germs, and as regards the presence or absence simultaneously of other pathogenetic organisms. The coexistence of phlyctenular inflammation, in any case, appears to favour the specific action of the Löffler bacillus, and so lead to the severer forms of diphtheria.

Although it is comparatively rare to find the fauces attacked, it is not so uncommon to meet with a true diphtheria of the surrounding skin, especially that of the eyelids.

Most frequently only one eye is affected, and in the severer cases there is always swelling of the preauricular glands.

A condition very similar to severe diphtheritic conjunctivitis, and, it may be, clinically indistinguishable from it, is sometimes caused by a streptococcus infection. There is reason to believe that this infection may be conveyed to the eye by flies or other insects.

In the *treatment* of conjunctival diphtheria there are two points which equally require consideration, namely, the local treatment and the general (antitoxin) treatment. Locally applied antiseptics must be directed against the specific bacillus and other microbes which may be associated with it. For this purpose removal of the membranes, and applications of chlorine water, freely painted on the conjunctival surface with a large camel's-hair brush, may be used twice daily. In addition, it is well to irrigate the eye thoroughly from time to time with a milder antiseptic, or simply with boiled water at a temperature of 100° F. Antitoxin injections up to 4000 units should be made in all severe cases, as well as in all milder cases in which bacteriological examination has shown the presence of the Löffler bacillus.

Trachoma is a specific and essentially chronic form of inflammation of the conjunctiva. It is characterised by a kind of hypertrophy of the mucous membrane, which is eventually always followed by atrophy and cicatrisation. The hypertrophy assumes both the papillary and the follicular type. In some cases throughout, and at certain times in the course of other cases, the one type is found to predominate.

Papillary hypertrophy occurs on the tarsal surfaces, and mainly in the upper lid. It does not differ in appearance from that met with in other affections of the conjunctiva in which the

papillæ undergo enlargement, such as in chronic blennorrhœa and ectropion. The difference lies solely in the subsequent connective tissue development, degeneration, and cicatrisation. The cause of this inherent difference has not yet received a satisfactory explanation.

The follicular hypertrophy in trachoma mainly implicates the conjunctiva of the retrotarsal folds. In this situation there may be seen, always some and often numerous, approximately spherical, grey, translucent bodies. They are visible through the superficial layers of the conjunctiva, the surface of which is rendered uneven by the way in which they protrude forwards. Where the papillary overgrowth is not too great they may also be seen in the tarsal conjunctiva, where they always appear to be smaller and more yellowish in colour. These are the so-called *trachoma granules*. They do not very markedly differ in appearance from the follicular masses which are seen in folliculosis of the conjunctiva in young people. In contradistinction to what is met with in that condition, however, the true trachoma granules are always present in greatest numbers in the upper lid. Whilst too, in the case of folliculosis, they become absorbed in the course of time without leaving any appreciable trace, in trachoma their disappearance is associated with cicatricial changes, which in the long run may amount to complete destruction of the mucous membrane.

It follows that while the true nature of the conjunctival hypertrophy in trachoma becomes easily recognisable in the later cicatricial stages, some doubt as to diagnosis is at least possible to begin with. It must be admitted, however, that some practised observers deny that the diagnosis of trachoma ever presents any difficulty from the first.

Trachoma occurs in an acute form accompanied by all the subjective symptoms of conjunctivitis, also by a distinctly purulent secretion. It is much more frequently nowadays met with as a chronic process, which until it leads to interference with vision, owing to corneal complications, may give rise to so little inconvenience as to be actually unsuspected by the individual affected. Not unfrequently acute exacerbations, accompanied as a rule by the formation of fresh granules, occur in the course of a chronic trachoma.

The cornea may suffer in two different ways: from *pannus* and *ulceration*.

Pannus is the most frequent complication. It is met with at some stage of the trachomatous process in most cases. Where there has only been a slight degree of conjunctival hypertrophy,

followed by early retrogression, pannus is not likely to occur, although it may immediately make its appearance along with a fresh attack in the lids. The clinical appearance of pannus is that of a superficial vascularised infiltration, spreading usually over the upper part of the cornea to begin with, and starting from the corneo-scleral margin. Great differences occur, according to the density, extent, and vascularity of this infiltration. It may in some cases be so great as to be quite fleshy looking.

Pannus is essentially a trachoma of the cornea, and consists of a cellular infiltration, with new-formed vessels, below the corneal epithelium. If it has not existed long, it is capable of absorption, and the cornea then regains its transparence. When the condition has been of long duration, however, the cellular infiltration has penetrated deeper through Bowman's membrane and undergone cicatricial changes, destroying at the same time more or less of the true corneal connective tissue, and thus leading to permanent opacity.

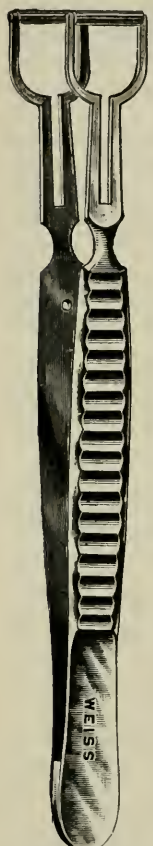
There is nothing particularly characteristic about a trachomatous ulcer. It may or may not occur in a part of the cornea affected by pannus. In any case it leaves, on healing, a permanent intransparency.

In long-standing cases of trachoma the tarsus itself becomes infiltrated, and subsequently undergoes a similar cicatricial change to that of the conjunctiva. This leads to trichiasis and entropion, and the inverted eyelashes, by injuring the corneal epithelium, pave the way for ulceration.

A certain amount of *ptosis* is very generally met with as an accompaniment of trachoma. This is probably due to a combined paretic condition of the unstriped muscular fibres which are inserted into the upper margin of the tarsus, caused by infiltration, and the increased weight of the thickened lid.

The frequency of trachoma varies very much in different districts and communities. It is mostly met with in low marshy countries, and in places where the population is crowded, ill-fed, and under altogether unfavourable hygienic conditions. In foreign towns the Jewish, and in our own the Irish, quarters present the largest percentage of trachoma. In Scotland it is a rare affection except amongst the Irish population. Prisons and barracks too are, and more especially have been, visited by epidemics of it. Armies, particularly in the East, have been visited by the same disease, which, as general attention was first given to it on account of Larrey's description of the state of the eyes of the French army in Egypt in 1798, is often called

Egyptian ophthalmia. Egyptian ophthalmia includes, however, many other forms of conjunctival disease besides trachoma. Trachoma is spread by contagion. The reason why it is most prevalent, wherever there is over-crowding, is that then the conditions under which contagion is most likely to take place, such as the use of towels, sponges, etc., in common, are most favourable. The contagious matter is the secretion. Consequently cases in which the secretion is copious are the most likely to spread the disease, though the same secretion is found not to produce equally acute attacks of trachoma in all individuals. It is now pretty well established that infection does not pass by the air, as was at one time supposed.



FULL SIZE
FIG. 42.—Knapp's roller forceps.

In the *treatment* of trachoma, attention must be given to cleanliness and ventilation. It is certainly inadvisable to allow anyone with this disease to sleep in the same room with others, or to use towels or sponges in common with anyone else. He should be well fed and kept as much as possible in the open air. In the acute form of the inflammation it is inadvisable, as a rule, to use astringents; at most, and only as long as the cornea is unaffected, a weak solution of subacetate of lead (2 grs. to the ounce), painted on the everted lids once daily, and boracic acid lotion as a wash, may be employed. When on the supervention of catarrhal inflammation there is a good deal of muco-purulent discharge, nitrate of silver solution, preferably weak (5 grs. to the ounce), may be cautiously applied to the everted lids. For the chronic cases there is certainly nothing better than bluestone. This should be applied daily to the everted lids, taking care to get the crystal (which should be smooth) well at the retrotarsal fold. Some cases do not tolerate sulphate of copper; and, in such, touching with a smooth piece of alum, or painting with the solution of lead, may be used instead. I have no experience of the treatment with jequirity, which is sometimes used.

Undoubtedly the treatment of many cases of trachoma may be greatly expedited by certain operative measures. Those I

have found most useful are expression of the follicles with Knapp's roller forceps (Fig. 42), and grattage with Jamieson's files (Fig. 43).

The roller forceps are suitable to begin the treatment with in all cases where the trachoma granules are present in considerable numbers. The method of proceeding is as follows: The patient is anæsthetised. The lid is then everted, and one roller end of the forceps is introduced and pointed as far up as possible into the transition angle beyond the retrotarsal fold, while the other roller rests on the tarsal surface close up to the lid margin. The rollers are then firmly approximated, and the forceps drawn forcibly towards the everted upper end of the tarsal conjunctiva until they drag their way free. This is repeated for different parts of the conjunctiva; and, finally, different folds of the lax retrotarsal portion of the conjunctiva are included between the rollers and given an additional squeeze. The patient is then put to bed, and iced compresses applied for some time to allay

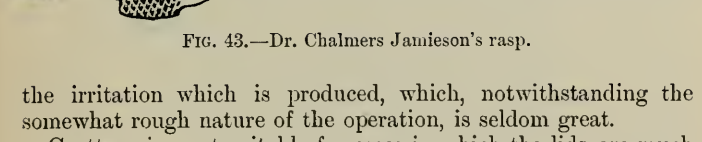


Fig. 43.—Dr. Chalmers Jamieson's rasp.

the irritation which is produced, which, notwithstanding the somewhat rough nature of the operation, is seldom great.

Grattage is most suitable for cases in which the lids are much thickened and the papillary swelling pronounced. It can be done under cocaine, the files being freely rubbed backwards and forwards over the tarsal conjunctiva. This has to be repeated many times at intervals of a few days, and gradually effects a reduction of the swelling. Sometimes it may advantageously be combined with the use of the roller forceps.

Attempts have also been made to cure the more persistent cases of trachoma by excising altogether portions of the conjunctiva in which the granulations are most abundant. This treatment is much practised in Königsberg, where the disease is of frequent occurrence, and is strongly recommended by Jacobson. Sattler, too, who has had a large experience of the treatment by excising the conjunctival fold, speaks well of it, although he mostly gives preference to a treatment which consists of rupturing the follicles with a cataract needle, and scooping out their contents with a fine circular sharp spoon, 2 to 4 mm. in diameter.

The accompanying pannus does not call for special treatment, having a tendency to improve or disappear with the cure of the conjunctival inflammation.

Amyloid degeneration of the conjunctiva.—This is a rare disease, clinically distinct from, though apparently having some connection with, trachoma. The appearance presented is that of yellowish and waxy-looking masses on the palpebral conjunctiva of both upper and lower lids, springing from the retrotarsal fold. The masses are usually very hard, and there is at the same time always a great enlargement of the tarsus. Portions excised give the characteristic reaction of amyloid degeneration. The exact nature of the process is differently described by various histologists. There seems little doubt, however, that the process is entirely a local one, as it is rarely, if ever, associated with similar degeneration elsewhere. The *treatment* recommended is the excision of the waxy masses along with the tarsus.

Essential shrinking of the conjunctiva.—Occasionally, and without any marked inflammatory symptoms at the time, an atrophy of the conjunctiva, or a complete growing together of its opposed surfaces, takes place. A connection between this degenerative change and pemphigus has been pretty certainly established. Cases of pemphigus of the conjunctiva are met with in which the eruption on the conjunctiva forms part merely of a more or less generally distributed skin affection of the same nature. Several cases of essential shrinking have come under my own observation, but I have only once seen the disease accompanied by pemphigus.

The *treatment* has been always without any effect, even where transplantation of mucous membrane from other parts has been tried.

Ecchymosis.—Any rupture or incision of the conjunctiva, produced either accidentally or by some operation, gives rise to effusion of blood into the membrane, which, according to its extent, takes from one to three weeks to undergo absorption. Spontaneous ecchymoses occur by the bursting of conjunctival vessels, usually owing to some excessive strain which has caused temporary congestion of the head—coughing, sneezing, vomiting, etc. A tendency to the occurrence of such ecchymoses indicates often a degenerated state of the vessels, and may therefore be of symptomatic importance.

Emphysema of the conjunctiva may occur alone or along with ecchymosis. In the latter case, some connection has been established between the air passages and the orbital tissues. The condition is rare.

Pterygium.—An inflammatory or hypertrophic thickening of a portion of the conjunctiva, of a triangular shape, firmly attached by its apex to the superficial layers of the cornea, has received the name of pterygium, owing to its fancied resemblance to the wing of an insect. The sides of a pterygium form distinct folds, under which a probe may be passed, often for a considerable distance. The folding-in of the sides gives an appearance as if some new membrane lay over the conjunctiva. Very considerable differences exist in the consistency of the pterygium. In some cases it is thin, pale, and fibrous; whilst the other extreme is represented by a swollen, red, fleshy elevation of the characteristic triangular form.

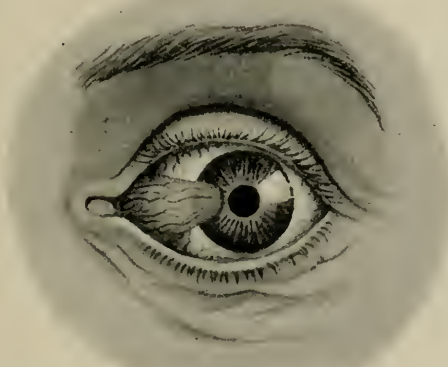


Fig. 44.—Pterygium.

The ordinary pterygium is always found in a position corresponding to the palpebral fissure, and therefore over one of the lateral recti muscles; much most commonly over the internus. Sometimes it exists in both eyes, and occasionally two are met with in the same eye.

Pterygium has a tendency in most cases to spread over the cornea, though it is rarely seen to extend beyond the centre of the pupil. It occurs only in individuals who are exposed to constant irritation of the conjunctiva, and in whom, at the same time, the conjunctiva is tolerably lax. It is therefore most frequently found in masons, field labourers, colliers, etc., and generally after the age of forty. The irritation to which they

are subjected causes, in all probability, not only hypertrophy of those portions of the ocular conjunctiva which are not covered by the lids, but a loss of the normal epithelial covering, so that there is a tendency for an adhesion to take place between the conjunctiva and the epithelial surface of the contiguous cornea, the vitality of which is also interfered with from the same cause. After such an adhesion has once taken place, the continuance of the irritation causes the surface of the conjunctiva to double over more and more on the cornea, and thus to extend its attachment with the superficial layers of the cornea, and at the same time drag more and more on the surrounding conjunctiva. A less common form, or what may be called a *spurious pterygium*, is met with at any part of the conjunctiva. It is the result of the attachment of a portion of chemotic conjunctiva to a subjacent ulcer of the cornea. Such cases only develop after severe inflammations, and do not extend. They also, as a rule, leave a complete space, which is bridged over, so that a probe may be passed from side to side below the fold of conjunctiva.

The *treatment* to be adopted in the case of pterygium should depend upon whether or not it is progressing in such a manner as to interfere with vision or with the free mobility of the eye. If this be the case, or if for the sake of appearance the patient wishes it to be removed, an operation should be performed. The most suitable and satisfactory method of operating is the following: The pterygium is seized with a pair of forceps held in the one hand, and the portion adherent to the cornea carefully dissected off with a small bistoury or Sichel's knife. When this is done, an incision is made from the cornea-scleral margin at the upper edge of the pterygium with a pair of straight scissors, in the direction of and extending to the centre of its base. A similar snip is made from the lower margin of the pterygium at the border of the cornea, meeting the first at a point. In this manner a lozenge-shaped piece is removed. Then there remains a raw surface in the conjunctiva, which is to be covered by undermining the conjunctiva above and below, and drawing it together with stitches. When this is properly done, it is rare to meet with any recurrence. It is essential, however, in order to ensure success, that the patient should not be exposed to the same irritation to which the original occurrence of the affection is to be ascribed, until some time after complete healing has taken place. When possible, it is advisable that he should change his occupation altogether for one which does not entail the same risk. In cases where, although there can be no doubt as to the gradual progression of the pterygium, the patient is nevertheless

unwilling to submit to operative interference, he must be protected against the constant irritation in some manner best suited to the requirements of each case. If he continues his usual occupation the eye should be tied up for a lengthened period. The spurious form shows no tendency to progress, and never recurs after operation.

Pinguecula.—Another change met with in the ocular conjunctiva of adults—sometimes, though not always, as the result of continued irritation from some cause or other—is what is called pinguecula. This is a whitish or pale yellow condensation of the conjunctival tissues covering the sclera, mostly to the inner and outer sides of the cornea, and corresponding, therefore, to that portion which lies opposite the palpebral fissure. The patch is often irregularly triangular in shape, and generally only very slightly prominent. Most commonly it is met with to the inner and outer side in the same or in both eyes, but more pronounced, as a rule, to the inner side. It does not cause any inconvenience, and does not call for operation. Pinguecula is a slow inflammatory thickening of the deeper tissues of the conjunctiva, which, although yellow in appearance, does not contain fat.

Injuries to the conjunctiva—Foreign bodies in the conjunctiva.—Clean cuts in the conjunctiva readily heal without giving rise to inflammatory reaction if the edges of the wound are brought together by stitches. Left to themselves, such wounds are apt to gape, so that healing takes place by granulation, and is therefore often accompanied by more or less conjunctivitis. Foreign bodies when retained in the conjunctival sac for days or weeks set up a traumatic conjunctivitis. They usually lodge somewhere under the upper lid, and mostly become fixed, with or without penetration, in some portion of the conjunctiva covering the tarsus, often close to the lid margin. Sometimes they become embedded in the folds of the retrotarsal portion of the conjunctiva, or owing to suction—as, for instance, in the case of husks of corn—lie with the concave surface against the conjunctiva. In the first position they are apt to give rise to ulceration of the cornea. Owing to this circumstance, it is well to make a practice of always everting the lids, and of carefully examining the conjunctival surfaces in all cases of inflammation of the conjunctiva, or of abrasion or ulceration of the cornea. Portions of glass are the most difficult to detect, so that when there is any suspicion of there being a foreign body of this nature present, the everted lid should be examined with oblique illumination, and, if necessary, with a magnifying glass.

Besides the cutting and contusion which may be caused by mechanical injury to the conjunctiva, and the subsequent changes, inflammation and cicatrisation, which result in this way, other and often more serious changes are caused by agents which have a chemical or thermal action.

Accidents from the introduction into the eye of acids, alkalies, lime, boiling water, or molten metal are not uncommon. As a rule such accidents are immediately followed by great pain, which leads the patient to seek advice as soon as possible. When, as usually happens, a portion of the conjunctiva has been destroyed, the prognosis will depend greatly on the extent as well as position of the injured portion. Except where the cornea is seriously damaged at the same time, the worst cases are those in which a considerable extent of both ocular and palpebral conjunctiva has been destroyed, and more especially when the destruction has involved the retrotarsal fold. It becomes, then, impossible to prevent adhesion of the lid to the globe, or what is called symblepharon. A symblepharon necessarily, too, gives rise to more or less restriction of the movements of the eye. It is often possible to remedy the defect by some operation; but it is of great importance to make an effort, in all cases seen soon after the accident, to avoid the formation of an adhesion between the two raw surfaces. This can, as a rule, be successfully accomplished, if the fold of transition from the ocular to the palpebral conjunctiva is not injured to any great extent, by frequently dropping a few drops of almond oil into the eye after washing it out with a weak non-irritating antiseptic lotion, and at the same time frequently separating the two surfaces. This treatment should, in any case, be adopted immediately after an injury has been received which is likely to cause destruction of the conjunctiva; but it must, of course, always be preceded by a thorough examination of the whole extent of the conjunctival surface, and the removal of any foreign bodies.

Foreign bodies of various kinds—dust, engine sparks, etc.—frequently remain adherent to the palpebral conjunctiva of the upper lid. The usual site for such foreign bodies to occupy is the conjunctival surface covering the tarsus, especially the portion of it which lies near the free lid margin. These can readily be removed by everting the lid. Attempts at removing them without eversion, with a camel's-hair brush, or the tip of the tongue passed below the upper lid, should not be made. When the suspected foreign body is not found on the tarsal surface, the fold itself must be properly inspected. This is often neglected. It is most readily done, by anyone not sufficiently

practised to do it with the fingers alone, by pressing a probe down on the skin of the lid, whilst it is held everted, and while the patient rotates his eye downwards as far as possible.

Electric light ophthalmia.—Amongst those whose eyes are subjected to the glare of a powerful arc light, an intense conjunctival irritation is sometimes found to come on several hours afterwards. The condition is exceedingly painful, accompanied by swelling of the lids and great photophobia. It has been shown by Widmark, by a series of beautiful experiments, that it is the violet and ultra-violet rays contained in the electric light which cause the characteristic irritation.

Snow-blindness.—Both as regards its symptoms and etiology,

Fig. 45.—Lymphangiectasis of the conjunctiva.

snow-blindness is closely allied to the form of conjunctival irritation set up by exposure to strong electric light. There is intense photophobia, swelling of the lids and chemosis, following upon the exposure for some hours to the light reflected from snow. As in the case of electric light ophthalmia, it is the irritation of the conjunctiva by the shorter, more actinic waves of light which gives rise to these symptoms.

Dark smoked glasses should be used as a protection wherever there is the risk of either electric-light or snow-blindness.

Lymphangiectasis of the conjunctiva.—A not uncommon appearance is met with in the conjunctiva, as the result probably of some interference with the normal flow of the lymph, and consequent dilatation of the lymph spaces. This change, which

seems to be of no importance, and not associated with any inflammation, consists in the formation of blebs of clear straw-coloured liquid, not bigger than a pin's-head, but crowded together in masses. The blebs are situated in the superficial layers of the conjunctiva, so that they can be readily pushed with the conjunctiva over the subjacent tissues (see Fig. 45). They often disappear spontaneously after some weeks or months.

Tumours and other affections of the conjunctiva.—Tumours of the conjunctiva are rare. Of the non-malignant forms perhaps the most common are papillomata. They usually occur as multiple excrescences from the conjunctiva, at the inner angle of the eye in the region of the caruncle, but are found at the same time springing from the palpebral conjunctiva. Their surfaces are generally uneven, often crenated, but they may also be smooth. If thoroughly removed, there seems to be no tendency to recurrence.

Fig. 46.—Case of dermoid cyst of conjunctiva.

Simple enlargement of the caruncle is sometimes met with.

Dermoid cysts of the conjunctiva are mostly situated at the corneo-scleral margin, and involve the cornea as well.

Of malignant tumours *sarcomata* of the conjunctiva are not so very uncommon. They are most frequently met with in the ocular conjunctiva. They may or may not be melanotic. Even when apparently very completely removed, they are extremely liable to recur. When, therefore, no doubt exists as to their nature,—as, for instance, when they are melanotic, and when in catching hold of them with the fixation forceps they readily break and bleed, and show themselves to be of a soft buttery consistence,—the best treatment, unless the other eye should be blind or absent, is to remove the eye, and at the same time a part or all of the contents of the orbit.

Rodent ulcers and *epitheliomata* are generally found as extensions from the skin of the lids, but they may originate in the conjunctiva. They must in any case be freely removed.

Tuberculous and *lupoid swellings* of the conjunctiva occur

as rare affections, the latter mostly spreading from the skin, while the former appear to originate in the conjunctiva. They both have a tendency to spread to the cornea. The differential diagnosis is by no means easy. Tubercle bacilli

Fig. 47.—Case of melanoid sarcoma of the conjunctiva.

have been found in some cases. The *treatment* consists in excising or thoroughly scraping away the soft tumour tissue.

Chancres occur occasionally in the conjunctiva, and involve the skin of the surrounding lids. They are not, as a rule, difficult to diagnose, but any doubt is set at rest by the appearance of secondary symptoms in a certain proportion of all cases.

CHAPTER VI.

DISEASES OF THE CORNEA AND SCLERA.

General Remarks on Inflammation of the Cornea.

The corneal tissue may be the site of inflammatory products, deriving their origin from a focus of inflammation which is situated either in the cornea itself, or in some other part of the eye. In the first case we may talk of a *primary* or true *keratitis*; in the second, there is, properly speaking, no keratitis, but merely a more or less dense, diffuse infiltration of the cornea, similar in every way to the hyperæmic and œdematous area of infiltration which surrounds a focus of inflammation in any other part of the body. The condition is one, then, of secondary diffuse infiltration of the cornea; secondary as distinguished from a similar infiltration surrounding a primary inflammation of the cornea.

Primary keratitis, except when confined to the epithelial layer, is mostly associated with some degree of destruction of the corneal tissue at the focus of inflammation, and the loss thus sustained is replaced by more or less intransparent connective tissue. It occurs in two forms—as an *infiltration*, and as an *ulceration*; that is to say, the inflammatory changes are either surrounded by more or less healthy tissue, or have led to a destruction of the superficial layers of the cornea, so that there is an open sore.

It is customary to distinguish between primary infiltration and abscess of the cornea. The latter is said to exist when the infiltration is purulent and destruction of the tissues has taken place. It is not always possible to make this distinction clinically. The colour of a corneal infiltration depends so much on the depth at which it lies, as well as on its density, that if one were to judge by colour alone, one would frequently diagnose an abscess when such did not exist in the anatomical sense. The degree of pain is also a very uncertain symptom, as great differences exist in this respect.

Clinically, then, we may divide primary corneal inflammation into *ulcerative* and *non-ulcerative*. The non-ulcerative frequently becomes eventually ulcerative. Both forms may be *single* or *multiple*, according as one or more foci of inflammation are present. They may be *superficial* or *deep*, *diffuse* or *circumscribed*, *vascularised* or *non-vascularised*, and may or may not be complicated by inflammation or other changes of any other part of the eye, such as iritis, scleritis, or any alterations in the contents of the aqueous chamber, such as the presence of pus (hypopyon) or blood (hyphæma).

FIG. 48.—Case showing extensive superficial vascularisation and ulceration of the cornea. An irregularly shaped central portion remains clear.

When healing takes place, the margin of an ulcer becomes rounded all over, owing to the extension over it of an epithelial covering, and the loss of substance is gradually repaired by the development of an intransparent connective tissue. There is thus left an opalescent or white opacity, a so-called *macula* or *nebula* of the cornea, as the result of the cicatrisation. An exceedingly dense white cicatrix is called a *leucoma*.

An ulcer which extends in depth may lead to perforation of the cornea. This may give rise to further complications, the nature of which depends on the situation and extent of the perforation. If small and central, there may be no further

complication than the emptying of the anterior chamber, whereby the lens comes in contact with the posterior surface of the cornea. When the lens remains long in this position there is apt to be set up a proliferation of the cells lining its anterior capsule, leading to what is called *anterior capsular* or *pyramidal cataract.* When the central perforation is large, the lens, and even more or less of the vitreous humour, may be expelled through it. Sometimes a perforation at the centre of the cornea remains for a long time open, constituting what is called a *fistula of the cornea.*

When a perforation occurs more towards the margin of the cornea, it is the iris which, on the escape of the aqueous humour,

Fig. 49.—Anterior synechia.

becomes applied to the posterior surface of the cornea. The most favourable result which may follow this accident is for the iris to go back into its proper position on the re-establishment of the anterior chamber. This happens if the perforation is small and rapidly closed. The portion of the anterior surface of the iris, which at the time of perforation becomes pressed up against the back of the cornea, may form a permanent fibrinous adhesion in this situation, and thus give rise to what is called an *anterior synechia* (see Fig. 49). There is then more or less interference with the free movement of the pupil, which, as it dilates less in one or more directions than in others, loses its circular form and becomes irregular in shape, usually oval or egg-shaped. In the case of larger perforations, the iris is entangled in the corneal

opening, and more or less of it may protrude or prolapse externally. The iris usually then becomes incorporated in the cicatrix. To this condition the name of *leucoma adherens* is given.

Corneal ulceration, when extensive or deep, leads also to alteration in the curvature of the cornea. Such an alteration may or may not be accompanied by more or less marked protrusion of the cicatrised portion, or what is called *staphyloma* of the cornea. A corneal staphyloma may be partial or complete, according as only a portion or the whole of the cornea is involved in the protrusion (see Figs. 50 and 53). The most severe cases of corneal destruction are followed by disappearance of the cornea—*phthisis corneæ*. Not infrequently a corneal inflammation is associated with, or leads to, inflammation of the iris.

Fig. 50.—Case of staphyloma involving a large portion of the cornea.

The principal *causes of primary keratitis* are traumata, either with or without subsequent sepsis, struma, and extension of conjunctival inflammations. The homogeneous elastic layer of Descemet, which, along with its layer of epithelium, bounds the true corneal tissue posteriorly, does not undergo inflammatory change. When perforation takes place after there has been an ulcerative destruction extending through the whole depth of the superficial layers, it is owing to the bursting of this membrane, which may for some time previously have been protruded into the ulcer, giving rise to the condition known as *keratocele*. After perforation there is usually observed a great tendency to healing.

The various diseases of the cornea are in all respects the most important of the common diseases of the eye. They are for the most part cases in which not a little good can be done by proper and judicious treatment, and in which much harm may result from wrong interference or neglect. Their importance lies in this, coupled with the value to vision of the normal cornea. There are other parts of the eye which are of course equally

valuable in this respect, but of few of them can it be said with equal justice that the treatment is often of great importance in influencing the consequences of the diseases by which they may be affected.

The main dangers to which the cornea is exposed by inflammation are, as we have seen, more or less serious permanent loss of transparency, and alterations in its curvature. Any collection of inflammatory products within the meshes of the corneal connective tissue causes an intransparency, and this, according to circumstances, may or may not be permanent. When there is no actual destruction of corneal tissue to account for some, at all events, of the inflammatory products, there need be, and generally there is, no permanent opacity left in the cornea. A localised inflammatory destruction, however, anywhere, is followed by cicatricial tissue formation, and this is always intransparent. In infants and young children, in whom the tissue changes are active, even cicatricial opacities may clear. This, however, takes place very slowly, as the connective tissue of the cicatrix gradually becomes replaced by corneal connective tissue.

The points in this connection which are of practical importance, then, with respect to both prognosis and treatment, are the recognition of interstitial infiltration opacities from cicatricial opacities, and the influence of the patient's age in the stability of the latter. Both forms of opacity may exist together. That is to say, we may find at some stage in the healing process an area of the cornea in which the opacity is due to cicatrisation, surrounded by one often considerably more extensive, in which the cause is merely an infiltration. It frequently happens too, that, owing to the latter obscuring more or less of the pupillary portion of the cornea, vision is much more interfered with than it eventually is, after all possible absorption has taken place. The surrounding infiltration can generally be recognised by its less pronounced whiteness and density. Further, its margins merge indefinitely into the clear cornea, never ending sharply, as does a cicatricial opacity. The surface of the cornea, the epithelium, is often irregular over the cicatricial opacity—never so, or at least only finely stippled, where the cause of the dulness is mere infiltration.

Although it is common to talk of opacities in the cornea from cicatrisation and infiltration, the loss of transparency does not in reality ever lead to real opacity. The tissues remain translucent, and it should be remembered that translucent nebulæ or leucomata in the cornea may interfere with vision, not only by excluding more or less of the light rays which should enter the

pupil to form the retinal image, but also by scattering those which they intercept. The scattered rays lead to a general blurring of the retinal images, by which the visual acuity is diminished. It is for this reason that tattooing of a nebula, with or without iridectomy, may lead to considerable improvement in vision.

Corneal ulceration is always primary, that is, it only exists where there has been a focus of inflammation in the cornea itself, never where the focus lies somewhere else in the eye, and the corneal changes are of the nature of an interstitial infiltration. It is useful to remember this from a prognostic point of view. Some ulcers invade the more superficial layers of the cornea over its whole extent, without passing so deeply as to lead to perforation. Others, again, more or less rapidly spread in depth, causing perforation, without a great extent of the cornea becoming involved. Ulcers at the corneal margin usually increase in size, in very much the same proportion in both directions, spreading superficially in a circular line round the margin, and at the same time eating through the thickness of the membrane.

From the point of view of *treatment*, there is more call for effort to be made to check the superficial extension than that which leads to an increasing breakdown of the deeper corneal layers. Both extensions have, of course, their natural limitations: the former ends when the whole of the cornea has suffered ulceration; the latter when perforation has taken place. As a general rule, however, healing is more apt to be delayed when the ulcer spreads comparatively superficially until all or most of the cornea has been destroyed; whereas the destructive process often ends after perforation, in the essentially deep ulcers. This fact may sometimes be taken advantage of, especially in deep marginal ulcers, when, by opening into the anterior chamber, by puncturing the floor of the ulcer, farther extension may be avoided. Such treatment must not, however, be resorted to unless other attempts at arresting the ulcerative process have first been tried without success. It is better, if possible, that there should be no perforation. There is a danger of in this way permitting the entrance into the deeper parts of the eye of microbes, which may be a source of very serious complications. The danger is greater, too, when the perforation is done as a surgical measure than when it occurs in the process of inflammatory destruction.

Nevertheless, paracentesis is often useful, particularly in the case of deep marginal ulcers, not only as tending to limit the extent of destruction to the cornea, but in preventing prolapse of iris, which is more likely to occur if the perforation takes

place spontaneously. Prolapse, too, when it does occur, is more easily dealt with if it follows a paracentesis, than if the hernia takes place through the base of an ulcer which has of itself yielded to the pressure from within. In the first case, it is recognised at the time, and can be replaced by a little careful manipulation, preferably with a thin pliable caoutchouc, or tortoise-shell iris-repositor, which should, of course, be aseptic. The iris can afterwards be kept away from the corneal wound by causing a forcible contraction of the pupil with eserine or pilocarpine. The worst that can then happen is an attachment of a point on the surface of the periphery of the iris to the back of the cornea, without any subsequent actual incorporation of iris tissue in the cicatrix which eventually comes to occupy the site of the ulcer. But even this may frequently be avoided. The following preparations of eserine and pilocarpine may be used for this purpose :—

℞ Eserinæ sulphatis	2 grs.
Acidi boracici	5 ,,
Aquæ destillatæ	½ oz.

℞ Pilocarpinæ nitratis	2 grs.
Acidi boracici	5 ,,
Aquæ destillatæ	½ oz.

After a paracentesis, too, the eye should be bandaged for forty-eight hours. The bandage should, however, be removed and reapplied every eight hours, to admit of the eye being well bathed, and the drops of the miotic solution used. Where there is much secretion, the changing may be done more frequently.

Prolapse occurring after spontaneous rupture is seldom discovered until some time after it has arisen—the incarcerated or protruding iris is then more or less covered with lymph. It is caught, too, in a more ragged and more structurally altered corneal perforation, and generally held sufficiently firmly to be with difficulty disentangled. Attempts at replacing the iris under these circumstances should not be made. They lead to laceration, and no doubt at the same time favour inoculation by the micro-organisms with which the incarcerated membrane is at least surrounded, and are very apt, therefore, to be followed by more or less serious iritis. As a general rule, it is better not to interfere at this stage at all. Even the use of mioties is probably best avoided. The ulcer may be carefully painted over with freshly prepared chlorine water to which a little hot water from the kettle has been added, so as to bring the temperature up to blood heat or a little over, then dusted freely with

very finely powdered (not sublimated) iodoform, and an occlusion bandage applied.

The subsequent treatment suitable for iris prolapses will depend upon the size of the protrusion. Often in the course of the healing process a pretty marked protrusion is found to diminish greatly in size. When this takes place, and the hernia has become flattened down to nearly the level of the cornea, and well covered by cicatricial tissue, it is best left alone. More marked permanent protrusions should, however, be excised. They are a source of greater risk, from their liability to injury. Disturbance of their cicatricial covering may, under certain conditions, favour inoculation by microbes, and lead to iritis and deeper inflammations of the eye. The excision should not be undertaken until all irritation caused by the corneal ulceration has subsided—generally not, therefore, until a fortnight or more after the prolapse has arisen.

The object aimed at in removing the prolapse is to flatten the protrusion down so as to bring it as nearly as possible to a level with the surface of the cornea. The proper way to do this is to transfix its base at about its centre with a small narrow cataract knife. The knife is then cut outwards in the direction at right angles to its edge, its surface being all the time kept parallel to and on a level with the cornea. When the one half has thus been separated, it is seized with a pair of fine-toothed forceps, raised so that the blades of a pair of scissors can be got to close below it, and at the same time over the remaining portion of the protrusion. A snip with the scissors, pressed somewhat downwards on to the cornea, can thus be made to sever the remaining half close to the corneal surface. Attempts at removing these prolapses with forceps and scissors alone do not lead to sufficient flattening, owing to slipping of the blades. After removal of an old prolapse, in the manner described, the eye may be tied up for four or five days.

In addition to the flattening down of a prolapse, cases in which this accident has happened sometimes call for further treatment. It happens not unfrequently that the pupil is visibly drawn in the direction of the corneal cicatrix. It loses its circular form, and becomes pear-shaped. Less pronounced degrees of this distortion and displacement of the pupil are of no consequence to vision, and are rarely the cause of any irritation. In the case of the larger hernias, however, the pupil may be rendered so eccentric that vision is thereby impaired; and besides, the dragging on the iris fibres, which is the cause of the displacement, may sometimes give rise to repeated attacks of congestion.

In such cases, two iridectomies should be done opposite to each other, at right angles to and on either side of the central point of the prolapse, or the synechia remaining after the prolapse has been levelled down. The iridectomies need not be large, and may both be done at the same time, though it is easier to allow some time—a week or more—to elapse before the second is done.

Iridectomy is also called for where the scar of a perforating ulcer—whether there be, as is most frequently the case, iris tissue incorporated with it or not—is weak, and begins to yield to the intra-ocular tension. This condition, *staphyloma*, may indeed often be arrested by iridectomy, especially when it is partial. Moreover, it is only then that any effort to prevent further loss of vision by serious changes in the corneal curvature can be of any avail. Other operations for more pronounced degrees of corneal staphyloma are not particularly satisfactory.

The *treatment* suitable for corneal inflammations, which do not present themselves as ulcerations, showing a marked tendency to perforation, must vary considerably according to their nature. The treatment of some forms has already been referred to in connection with conjunctivitis, but before discussing that which may be recommended in others, there are a few more general practical points to which attention may be directed. It is necessary to bear in mind, for instance, in connection with keratitis, that the origin of the local inflammation is perhaps most often to be found in that of some neighbouring part of the eye. One's attention should therefore always be directed to the state of the lid margin, conjunctiva, and tear sac. And this, even where the history points more or less clearly to some preceding trauma. In many cases, too, the state of the general health will have to be inquired into, and demand appropriate treatment. This is particularly the case in struma, syphilis, diabetes, rheumatism, and gout, but also, though less commonly, where other digestive or circulatory or nerve disturbances exist, or where functional or organic disorders of the reproductive system are present. In short, though local treatment may be indicated, it is comparatively seldom that nothing further is called for.

Local treatment is least essential in the case of mere infiltration, both superficial and deep, and most in the more virulent, rapidly spreading, ulcerations which have a septic origin. It used to be a common practice to content oneself with the occasional or frequent use of atropine dropped into the eye. This has no further effect on the local inflammation than to act to some extent as an anodyne. Cocaine is much more useful in this respect,

and therefore should be substituted for atropine where there is no complication with iritis. In all cases, however, the state of the iris should be looked to, and, where any marked congestion or any inflammation of that membrane exists, atropine should be used. In many cases, indeed, of bad ulcerative keratitis, a subacute iritis begins to show itself after the corneal condition has existed for some time. The iritis is no doubt caused by the action of toxins which pass through the cornea into the aqueous humour.

All the different alkaloid solutions, used as "drops" for the eye, should be freshly prepared, and be made up with some antiseptic. They are otherwise apt to contain mycotic or other germs, and then likely to do more harm than good, by causing conjunctivitis, and thus indirectly tending to keep up or even aggravate many corneal inflammations. The pipettes or glass rods used for introducing the drops should also be rendered aseptic before use, and should never be brought into direct contact with the conjunctiva.

In using cocaine, it must be remembered, too, that the anæsthesia which it produces is liable, by causing an arrest of the tear flow and of the other secretions by which the eye is normally lubricated, to give rise to a desiccation, or even, in extreme cases, a shedding of the corneal epithelium. It is therefore well to tie up the eye for some time after its application. On this account, it should not be too constantly applied. It is useful often, and especially where the corneal condition is associated with much photophobia, to precede the examination of an inflamed cornea by an instillation of cocaine. The cocaine drops, suitable for this and other purposes, may be prepared according to the following prescription :—

℞	Cocainæ hydrochloratis	4–10 grs.
	Acidi boracici	4 ,,
	Aquæ destillatæ	2 drms.

Eserine is now more frequently used in most corneal inflammations than atropine. I have never found it to have any effect on the course of the inflammation, and consider that its use should be confined to cases where, from possibility of peripheral prolapse of iris, it is advisable to obtain a powerful contraction of the pupil.

In many corneal conditions one sees exemplified, in a way which in other parts of the body is not so readily followed, the struggle which takes place between the vitality of the tissues and the external forces, micro-organisms, toxins, and other irritants

which tend to destruction. The basis of one's treatment should therefore be, in the first place, either altogether to avoid measures calculated to diminish or inhibit the former, or make use of measures by which the vitality is temporarily increased without a swing subsequently taking place in the opposite direction. Again, our efforts must be directed towards neutralising and keeping in check the activity of the external irritants, in a manner, too, which does not impair vitality.

Both heat and cold have important influences in these respects. The application of ice, which was formerly much in vogue, has been found practically to be worse than useless. Possibly, if the temperature of the cornea could be constantly kept at the freezing-point of water, the use of ice might occasionally be of some value. The usual way of applying cold by iced compresses does not maintain the desired low temperature, and no doubt the explanation of the harm done by this treatment is the disproportion which it establishes between tissue vitality and activity of external irritants. By the ordinary applications, the lowering of the former is not compensated for by the degree of inhibition caused in the latter. This disproportion is indeed much less in the case of the different antiseptic preparations, which may be used both more efficiently and more conveniently. But inasmuch as these no doubt to some extent lower the vitality of the cornea, it is often advantageous to combine with their use that of heat directly applied. Practically, it is found, however, that although heat is more efficacious than cold, its application can be overdone. It is certainly not suitable in all cases.

The effect of heat must be got as far as possible without that of poulticing. The simplest way to do this is as hot fomentations, lasting a quarter of an hour or so, every two or three hours. Dry heat may also be used, but is more troublesome to apply, and has no particular advantages. Poulticing in any form is always more or less hurtful.

The advisability of tying up the eye or not is a question which often presents some difficulty. In itself, it would seem to afford a natural means of keeping the eye at rest. In point of fact, it is, with certain exceptions, a useful treatment when properly done. But it must be remembered that there is some danger, and, in certain forms of corneal inflammation, great danger, of the tying up causing a poulticing action and a retention of the secretions, both of which may entail much more risk than is run by leaving the eye uncovered. Bandaging should therefore not be continuous, but the bandage should be removed two or three times or oftener during the day, and need not be applied at all at night. At each

removal, the eye should be properly bathed with boracic lotion or hot water, which has sufficiently cooled after boiling, and any other local application made which may be considered necessary. On account of the frequent necessity for removing the bandage, it should be in a form which can readily be replaced by the patient himself. A good form of occlusion bandage for this purpose is a piece of flannel 6 in. long and $2\frac{1}{4}$ in. wide, to each corner of which a piece of tape is sewed. The two tapes at each end converge into one. The bandage is applied over a pad of Gamgee tissue or absorbent cotton-wool. It is carried diagonally over the eye—the two long tapes being crossed at the back of the head and tied over the forehead. It should be tied comfortably tight. Knitted bandages similar in shape are also good.

The different local applications which may be used in cases of corneal inflammation (in addition to yellow oxide of mercury, which it must be remembered is only suitable in strumous or eczematous superficial keratitis) are—iodoform, chlorine water, and boracic lotion, tincture of iodine, nitrate of silver, pure carbolic acid, and the actual cautery.

Iodoform is an extremely useful application, which may be used either finely powdered (not sublimated), or as an ointment in the proportion of 1 in 8. Gelatin discs, containing iodoform, have also been used. They, however, melt rapidly, and leave very little iodoform. On this account, it is much more satisfactory to dust the pure iodoform on to the cornea. This may be done freely. The ointment, too, is not so good, but is more readily applied by the patient himself, and is, moreover, more suitable when the eye is not afterwards bandaged.

Chlorine water need only be used in severe ulcerations which are rapidly spreading, either superficially or in depth. It may be used both in the form of a wash or injected subconjunctivally. The subconjunctival injection should be made with a hypodermic syringe, introduced at two or three different points. Five or six drops may be injected at each point. The chlorine water is more diffusible, and does not cause any more pain at the time, or any more reaction afterwards, than solutions of corrosive sublimate, which are more generally used. Chlorine water must be freshly prepared. If it has stood for some time it causes much more irritation, and is besides less efficacious. As a subconjunctival injection, it should be used fully saturated. In the same full strength, it may be freely dabbed on to the surface of a corneal ulcer with a camel's-hair brush. As a wash, it is better to use the fresh saturated solution, mixed with about twice its volume of warm water.

Boracic lotion is suitable for all cases, even where the inflammation is confined to localised infiltrations. It is the most convenient way of keeping the eye clean by removing the conjunctival secretions. It may be used saturated and mixed with some hot water, so as to bring its temperature up to that of the body. The best plan is to trickle it into the eye, squeezed out of a pledget of absorbent cotton-wool, which is thrown away after it has been used. The patient may do this fairly well himself, by throwing back his head, and holding down the lower lid with the one hand.

Tincture of iodine is only called for in the severer cases of ulceration. It is applied directly to the ulcer with a camel's-hair brush. It is a fairly good substitute for the actual cautery, when that is not at hand. In some cases its application may be preceded by scraping the ulcer, which can be done painlessly under cocaine. In less severe, more superficial, and especially vascularised ulcers, which are not of strumous origin, the iodine may be used as an ointment. A convenient form is as a 1 per cent. solution of pure iodine, in purified white vaseline. This should be rubbed on to the everted conjunctival surfaces with the point of the finger, and the lids then allowed to close over it. It produces only slight irritation as a general rule. For strumous superficial vascularised ulcers, the yellow oxide of mercury has already been referred to as the most efficacious application.

Nitrate of silver in solution is a very useful agent in all cases of superficial non-vascularised ulcerations. It is particularly to be recommended in ulcers of this kind, in which the base of the ulcer is more or less markedly infiltrated, but which the absence of pus in the anterior chamber (hypopyon), and more especially of any deep purulent infiltration of the margins, show to be not of the most dangerous septic order. Catarrhal ulcers in old people, to which reference has already been made, are especially benefited by one or two applications directly to their surface of a 2 per cent. solution. It is well to remember that it is inadvisable to repeat the application too frequently. The practical guide is afforded mainly by the extent to which the use of the caustic solution has relieved the pain. If, the next day after its application, the pain is found to be much less, it should not be used again. A careful examination of the ulcer will then reveal indications of healing. The rough, ragged margins will have become more or less rounded, owing to epithelial growth. One's object is merely to induce healing, and further applications only destroy the newly formed epithelium, and thus interfere with the natural process of reparation.

Pure carbolic acid, applied directly on a wooden match, is a useful disinfectant for the severer forms of septic ulcer when a suitable actual cautery is not at hand. The actual cautery is undoubtedly the best means we possess of checking the spread of a serpiginous septic hypopyon ulcer of the cornea. Cases of this kind are very frequent, and are the principal cause of unilateral blindness. They almost invariably originate in some more or less trifling injury to the cornea, by which some portion of its epithelium is denuded, and its deeper layers inoculated with septic matter, which may be introduced either by the body with which the injury is caused, or by micro-organisms which exist at the time in the conjunctival and tear sacs. The importance of this latter connection has already been considered. In the treatment of these severe destructive corneal inflammations, much depends often upon the efficiency with which the actual cautery is applied. In some cases, however, the virulence of the process is so great that it may be impossible to check it. In such cases, the specific microbe at work is generally either the pneumococcus or the gonococcus. The two best means of applying the actual cautery are by means of the galvano- and the thermo-cautery. Provided the thermo-cautery point used is a fine one, so that its action can be properly limited, it is in every way equal to the other. The cautery should be made to burn sufficiently through all the deeply infiltrated margins of the ulcer. It is by these abscess margins that the ulcer spreads, and they must be properly destroyed. The other portions of the ulcer, and there are usually some such, which do not present infiltration at the margin,

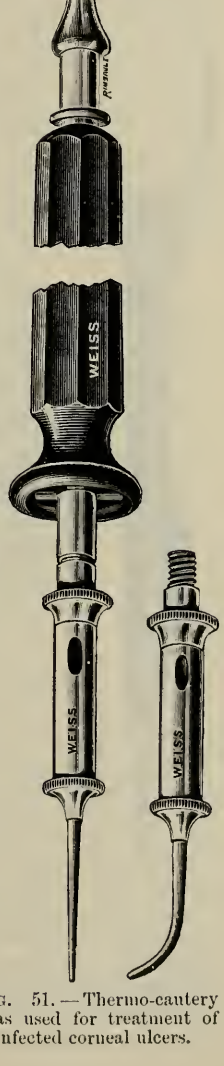


FIG. 51. — Thermo-cautery as used for treatment of infected corneal ulcers.

may be left. By using cocaine, the little operation may be done without causing pain.

The indication that the process has been arrested by this proceeding is afforded by the diminution subsequently of pain, by the diminution in the amount of the hypopyon, and the more satisfactory appearance of the ulcer margins. These septic ulcers are often very painful, and may for nights interfere with sleep. After efficient cauterisation, the patient is able to sleep, the hypopyon diminishes in amount, and the edges of the ulcer appear clearer, or merely, it may be, slightly charred. The subsequent treatment should consist in the use of chlorine water as a lotion, and iodoform in the manner just described. It is sometimes necessary to repeat the cauterisation. This should be done on any return of pain, if, at the same time, a little yellow point of infiltration shows itself at any point of the ulcer margin.

Fig. 52.—Galvano-cautery.

Should a really efficient application of these measures, repeated, it may be, once or twice, fail to arrest the process of destruction, the best plan to adopt is to open freely into the anterior chamber through the base of the ulcer. This treatment, by what is called Saemisch's section, at one time constituted one of the great advances in ocular surgery. Now that the actual cautery is used, it is comparatively seldom called for. A narrow Graefe cataract knife is entered at one side of the ulcer, passed across the anterior chamber, and brought out again at a point beyond the opposite margin, and then made to sever the whole base. In doing this operation, the part selected should, as far as possible, be made to include the margins which are most infiltrated. The moment the section is made, and the hypopyon escapes, there is a sudden hyperæmia of the iris, the vessels of which may even give way, and great, often agonising, pain experienced. This pain passes off in a few minutes, but it is as well to know that it is sure to occur.

Something has already been said, though mainly with reference to prognosis, of the opacities which remain in the cornea

after the subsidence of an inflammation. The area of intransparency may be due, as we have seen, to either infiltration or cicatrisation, or both. The question as to what, if anything, can be done to hasten or promote the clearing away of these intransparencies will often present itself. Cicatricial opacities, in adults at all events, remain indefinitely practically the same, and no treatment is known by which they can be removed. Different stimulating and irritating applications have been tried. Repeated puncturing with fine needles and electrolysis have also been resorted to, with, however, absolutely no effect. Attempts have been made, too, at different times and in different ways, to transplant portions of clear cornea from other eyes, human and

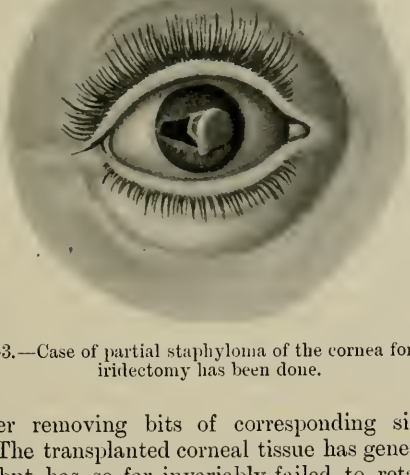


FIG. 53.—Case of partial staphyloma of the cornea for which iridectomy has been done.

animal, after removing bits of corresponding size from the opacities. The transplanted corneal tissue has generally retained its vitality, but has so far invariably failed to retain its transparency, and thus the final effect of the operation has been nil.

It is otherwise with opacities which are the result of infiltration alone. The general tendency with these is to clear away more or less completely, and with varying degrees of rapidity. Their absorption is often slow, and indeed seems, in some cases, to come to a standstill altogether. In such cases there are various means at one's disposal which are to some extent of use in promoting and stimulating the desired absorption; of these, the ones chiefly to be recommended are: massage of the cornea,

iodine, turpentine, and sulphate of copper. In very severe cases of dense pannus, the irritation necessary to promote absorption may even be got by inducing a purulent conjunctivitis.

Massage of the cornea is best done through the lid. The lid is rubbed quickly over the cornea, and with gradually increasing force, for half a minute, or more, at a time, once or twice daily. To do this effectually, the rubbing must give rise to a moderate degree of surrounding hyperæmia. The massage may also be combined with the use of the iodine ointment already referred to. A good and not too strong stimulating effect may be got by the daily use of the following prescription :—

℞ Olei terebinth.	1 drm.
Olei amygd.	2 ,,
Sig. Eye-drops.	*Misce.*

Sulphate of copper is most useful in trachomatous pannus. It should be used in the shape of crystals, from which the sharp edges and points have been ground down. The inner surfaces of the lids are lightly touched with these crystals, and some of the salt is then dissolved in the tears, and is thus brought in contact with the cornea.

The very serious consequences to the cornea which are likely to accompany purulent conjunctivitis must necessarily greatly limit the application of the last measure, which has been referred to as a means of stimulating absorption in the case of dense infiltration opacities. The vascularised cornea is, however, better able to withstand the destructive influence of the gonococcus. In dense vascularised pannus, which has given rise to so much intransparency as to practically destroy vision altogether, it is sometimes justifiable, in view of the possible brilliant results which may thus be obtained, to inoculate the eye with some of the discharge from a case of true gonorrhœal conjunctivitis. This is, however, only justifiable if both eyes are affected. The risk should not be run as long as one eye has retained sufficient vision to enable the patient to find his way about, on account of the possibility of its being also attacked by the specific inflammation. Such an accident might happen as the result of any inefficient application of the means which have been referred to by which the sound eye may be protected. In any case, before adopting a cure of such severity, the patient must, of course, be made fully aware of the suffering he will have during the first stage of the inflammation, and of the risk of complete destruction of the eye with which it is associated. The inflammation, too, must be kept in check as far as pos-

sible by the antiseptic measures which have already been described.

Another less severe method, but at the same time one which is far less effectual, though entailing no risk of the loss of the eye, is to perform the operation of peritomy. This consists of removing a ring-shaped portion of conjunctiva immediately surrounding the cornea. To do this the conjunctiva is circumcised with a pair of scissors, at a distance all round of about $\frac{1}{6}$ in. from the cornea. It then retracts, leaving a gaping wound, which is further enlarged by cutting away bit by bit the annular portion which surrounds the cornea. Each bit is seized with a pair of fixation forceps, and cut off close up to the cornea with scissors. The wound is then allowed to cicatrise without any stitching, and under the ordinary antiseptic precautions. The cicatrisation, which slowly takes place, has the effect of causing the greater or less disappearance of the superficial new-formed vessels in the cornea, and, with them, of some of the infiltration.

Many forms of primary keratitis are of comparatively rare occurrence. Their proper local treatment will usually be on the lines already discussed from a more general point of view.

In the case of superficial ulcers which show a marked tendency to recurrence at frequent intervals—once a month or oftener—the cause of recurrence may often be found to be evidently due to insufficient tenacity or vitality of the epithelium which in the process of recovery is formed over the site of the ulcer. There is thus a tendency for this epithelium to be shed or separated from the underlying tissues in the form of a bleb, often of considerable size. No doubt this occurs owing to some slight injury, such as forcible rubbing of the lid over the eye. Such an injury, however, often occurs during the night, so that the patient is unable to give any other history of the cause than that of suddenly awakening with the feeling of intense pain in the eye. Such a history should always lead one to make a careful examination of the cornea, and it will usually be found that, by sliding the lower lid over it, some portion of its epithelium wrinkles up and reveals the presence of a collapsed bulla. The treatment which should then be adopted is to drop some cocaine into the eye, strip off the detached epithelium with a pair of iris forceps, wash with warm boracic acid solution, and apply a bandage.

With regard to the treatment, other than local, of corneal inflammations, it is difficult to give any precise directions. As a general rule, medical treatment in such cases is of com-

paratively little importance. Yet it is always advisable to take the general health into consideration. Often one has to deal with essentially strumous individuals, in whom the diathesis has a more or less direct connection with the local inflammation. The same is true, though to a less extent, in gout, rheumatism, dyspepsia, and anæmia. Possibly, also, uterine and other female disorders may sometimes have an influence; they certainly have in connection with some deeper affections of the eye. Much may be done by dieting, Turkish baths, massage, and change of air. The drugs which may be used with more or less reason are iron, arsenic, quinine, salicin, and iodide of potassium.

In certain recurring types of corneal inflammation, baths appear to do good. I have repeatedly sent patients to Strathpeffer, Buxton, Harrogate, Droitwich, and Bath in this country. Others, again, have derived benefit from one or more visits to Aix-les-Bains, Contrexeville, and Brides-les-Bains, in France; and Wiesbaden, Ems, Nauheim, Schwalbach, Schlangabad, Carlsbad, and Kissingen, in Germany. I have also found some of the higher health resorts in the Engadine and in Norway of great use in the treatment of strumous and tuberculous forms of corneal inflammation.

Special Forms of Primary Keratitis.

Phlyctenular keratitis.—This very common affection is not properly characterised by the name which it most frequently gets. But as it is the process in the cornea which corresponds to phlyctenular conjunctivitis, with which it is very frequently associated, there seems no reason to prefer such names as scrofulous or lymphatic keratitis, or herpes, or eczema of the cornea, which have been by some substituted for it.

Phlyctenular keratitis occurs in the form of single or multiple, small, superficial, and, at first, usually non-vascularised, infiltrations of the cornea. The size of these infiltrations is rarely more than a pin's-head. They are of a greyish colour, and slightly prominent. Frequently they break down into small ulcers, which do not as a rule exhibit any tendency to spread either superficially or in depth, but which frequently become vascularised. A slight nebulous spot remains for some time after healing has taken place, but eventually disappears entirely. Sometimes the little infiltrations are decidedly yellow or purulent, and break down into ulcers, which lead to destruction of some of the true corneal tissue, and therefore to more permanent nebulæ. A certain, and often considerable, amount of pinkish

circumcorneal injection is met with in this affection, and there is at the same time almost invariably a good deal of lachrymation and photophobia. The photophobia is often so intense in children as to lead to most persistent blepharospasm. The most common cause of phlyctenular keratitis is struma, but it is often met with where there exists some constitutional depression not necessarily of a strumous nature, such as weakness after exhausting illnesses, measles, scarlet fever, etc. In strumous children it is very apt to recur once a year or oftener for some time. Altogether the affection is much more common in children than in adults, and usually, when met with in adults, there is a history of previous attacks in childhood.

Except in more markedly purulent cases, the *treatment*, in children at least, should consist mainly in the local application once daily of the yellow oxide of mercury ointment (Pagenstecher's) of the strength of 8 grs. of the yellow oxide to 1 oz. of unguentum cetaceum, to which a few drops of almond oil may be added to keep it from becoming hard. Spermaceti is better than vaseline, which sometimes irritates. This ointment is certainly better than any other form of mercurial preparation. Whether this is owing to its stimulant or its antiseptic properties, or to some other cause, is not very evident. Adults do not tolerate it so well as children. They require altogether less stimulating local treatment; atropine, cocaine, and weak antiseptic applications, such as a 2 per cent. boracic lotion, or a lotion of corrosive sublimate, 1 in 5000 or 10,000. The internal administration of cod-liver oil is of great service in children. Attention should also be given to keeping the skin clean. For adults, quinine, or, in the strumous, the syrup of the iodide of iron, are indicated. Tying up the eye is not only unnecessary, but does harm, partly on account of encouraging the photophobia, and partly owing to the poulticing action which is apt to be caused by the bandage or cloth when saturated with the tears which are usually copious in this affection. At most a shade may be allowed on account of the photophobia, but it is better as a rule to try in every way to combat this condition.

The photophobia is sometimes so severe, and at the same time so out of keeping apparently with the actual severity of the inflammation, that it must be looked upon more as an induced neurosis which calls for special treatment. (See p. 118.)

Fascicular keratitis.—Closely allied to phlyctenular keratitis etiologically, and indeed often occurring along with it, but constituting a distinct clinical type of corneal inflammation, is what is called fascicular keratitis. This is a vascularised infil-

tration, the vessels in which run parallel to each other, so as to form a dense band or fasciculus about a line in breadth stretching into the cornea (Fig. 54). At the end of the vascular leash the infiltration is somewhat more or less crescentic in shape, and often ulcerated. Occasionally two or more of such infiltrations are to be seen stretching in towards the centre of the cornea, and although most commonly the course taken is a straight one throughout, there is sometimes a more or less decided bend made. When devascularised, a nebulous streak is left, which very slowly clears away, and is always most dense and persistent at the end farthest into the cornea. This portion

Fig. 54.—Fascicular keratitis.

often remains indeed a permanent opacity. The accompanying symptoms—circumcorneal injection, photophobia, and lachrymation—are the same, and exhibit much the same differences in intensity, as in the case of phlyctenular keratitis. The affection is mostly strumous, and almost entirely confined to children. The *treatment* is the same as for phlyctenular keratitis, only in these cases Pagenstecher's ointment is even more valuable, and seldom fails to arrest the progress of the inflammation in a few days. It causes first of all a gradual disappearance of the band of vessels, and subsequently promotes absorption of the infiltrating cells. It is important to check the progress before the centre of the cornea is reached, as the opacity left is of course

of much more serious consequence if situated directly in front of the pupil. Where, at the time the case comes under observation, the portion of the infiltration at the end of the fasciculus of vessels should happen to occupy just the centre of the cornea, it is better to allow it to be pushed, as it were, a little farther before trying to check it, so as to allow the pupillary area to be occupied by a vascularised portion, which is more completely absorbed, and therefore does not eventually interfere so much with vision.

Pannus.—This consists for the most part of a development

Fig. 55.—Showing the condition of pannus in the upper portion of the cornea, also cicatrices in the conjunctiva of the upper lid in a case of trachoma.

of new vessels in the superficial layers of the cornea. The vessels spring from those of the conjunctiva, and course immediately below as well as above Bowman's membrane. At the same time there is more or less irregularity of the corneal epithelium over the vascularised portion, and some diffuse infiltration into the tissues occupied by the newly-formed vessels. There are great differences both in the extent and intensity of the vascularised area. When very dense the cornea assumes quite a raw fleshy appearance, a condition known, therefore, as *pannus crassus.*

Pannus occurs principally in connection with trachoma (see Fig. 55) and long-continued strumous infiltrations of the cornea. We may therefore distinguish a *trachomatous pannus* and a *strumous pannus*. Trachomatous pannus is apparently due to an extension of the granular inflammation from the conjunctiva to the cornea. In many cases, where the granulations are massive, there is found to be no pannus; while in others, again, a marked degree of pannus is associated with comparatively slight alterations in the palpebral conjunctiva. This disproportion between the condition of the conjunctiva and cornea in different cases shows that the latter is not the result of friction, though this connection has been assumed from the fact that the

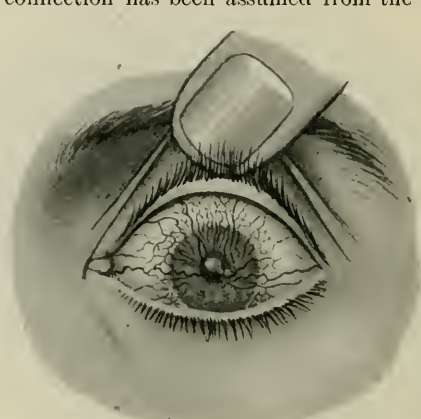


FIG. 56.—Strumous pannus, showing large development of superficial vessels in upper part of cornea.

pannus often occupies only the upper portion of the cornea, extending over an area corresponding to that covered by the upper lid. One frequently sees a pannus all at once set up, along with an acute exacerbation in the conjunctiva, in cases which have long remained free from corneal complication. In spring catarrh, too, in which the roughness of the conjunctival surface may attain a degree rarely if ever seen in trachoma, there is never any pannus. Strumous pannus is more frequent in young adults than in children. It is always a very chronic affection. Sometimes the infiltrations extend in depth, and become purulent, leading eventually to actual perforation of the cornea. The opacity produced by pannus may, in course of time, disappear under treatment, the vessels becoming first

attenuated and less numerous. Long-continued cases often result in a hopeless opacity from a kind of cicatricial organisation of the infiltrated cells. Some, again, lead to alteration in the shape of the cornea, deepening of the anterior chamber, and eventually also to changes in the iris, with secondary glaucoma. An indication of the presence of such deeper complications is often afforded by a marked intolerance to the usual local applications. In other cases, perforation, followed usually by more or less shrinking of the eye, may take place.

The *treatment* of trachomatous pannus mainly consists in treating the conjunctival affection. The strumous form is best treated, unless it has gone on to ulceration, with Pagenstecher's ointment and massage, in the shape of friction through the lid,

FIG. 57.—Case of small infected corneal ulcer with hypopyon.

along with suitable general treatment. Very long-continued dense cases of pannus may sometimes (see p. 152) be caused to clear up by inducing a purulent inflammation of the conjunctiva. Many cases are much benefited by the operation of *canthoplasty* for the enlargement of the lid aperture.

Hypopyon keratitis.—A good many deep-seated abscesses of the cornea are associated with hypopyon, an accumulation of pus in the anterior chamber. Not infrequently this complication is met with in the more severe cases of strumous corneal inflammation, which occur mostly in children. Great differences exist in the density of the hypopyon; when very thick and fibrinous, it may not fall down to the bottom of the chamber, but remain sticking to the posterior surface of the cornea.

A very distinct clinical form of inflammation of the cornea is what is usually in this country specially understood by the term *hypopyon keratitis*, owing to its always being complicated with the appearance of pus in the anterior chamber. This affection occurs as an ulcer, some part of the irregular margin of which is densely infiltrated with pus. The characteristic feature of the ulcer is that it extends in the direction of this infiltrated margin, for which reason it has received the name, more expressive of its serpiginous nature, of *ulcus corneæ serpens* (Fig. 58).

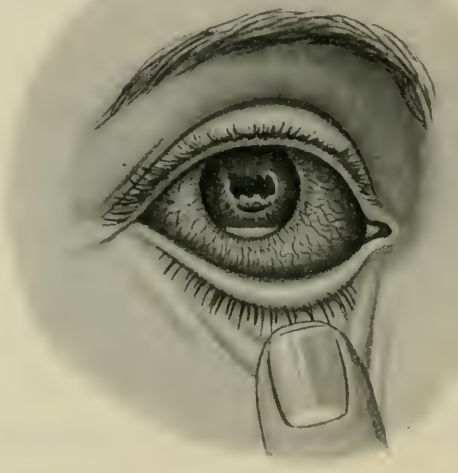


FIG. 58.—Case showing irregularly shaped spreading margin of infected corneal ulcer with hypopyon (hypopyon keratitis).

The origin of this form of keratitis is in almost all cases a trauma, which has been followed by an inoculation with pus from a previously existing dacryocystitis or chronic conjunctivitis. Those whose occupations cause their eyes to be subjected to continual irritation, as well as occasional injuries, are most liable to contract this inflammation. The inflammation is of a septic nature, and caused by the presence of microbes which exist in the discharges from chronically inflamed mucous surfaces. As the ulcer extends, more and more pus finds its way into the anterior chamber. Although absorption of the pus no

doubt constantly goes on, yet, as long as there is any active inflammation in the cornea, it is more rapidly secreted than absorbed. Increase in the amount of the hypopyon is therefore a certain evidence of progress in the process of destruction in the cornea. As long too as the yellow margin of infiltration exists in the cornea, extension is taking place. The natural course of the inflammation is for the ulceration to go on spreading, until the whole of the cornea in the direction of the creeping infiltration has become involved; and as this often takes place in two or more directions, seldom in all at the same time, it is not an uncommon thing for the whole cornea to be ulcerated.

The complications of hypopyon keratitis are those already described as met with in connection with severe ulceration, though, owing to the greater tendency to superficial as compared with deep spreading, the more serious complications are not very frequent.

The *treatment* should be directed to first destroying the area of infiltration and then applying antiseptics. The way in which this may be done has already been referred to (see p. 149).

If the ulcer has been central, as is often the case, it is necessary subsequently to perform iridectomy, so as to displace the pupil to opposite a clear portion of the cornea. In most cases it is advisable at the same time to treat the tear sac in the manner already described. Owing to the tendency to iritis, it is well to keep the pupil dilated until the healing process has advanced to such a stage that there is no further danger of such a complication.

Dendriform (mycotic) keratitis.—The characteristic of this inflammation is a great tendency to a kind of ramifying superficial extension (see Fig. 59). It is a very chronic affection, and the amount of infiltration surrounding the ulcerated rills which it forms is so slight as to render the peculiarity of its propagation liable to escape detection, unless a proper examination be made by oblique illumination. The pain caused by this inflammation is, as a rule, slight, though sufficient to give rise to some discomfort and photophobia.

When uncomplicated, dendriform keratitis is always superficial and not accompanied by hypopyon. In not a few cases, however, which begin in this way, and no doubt as the result of inoculation with more active micro-organisms, a serpiginous hypopyon ulcer may make its appearance. The cause is not known, though it is evidently a mycotic one. It is best treated by dabbing on to its surface some absolute alcohol with a camel's-hair brush. Usually after the first application the symptoms

subside, and the treatment need only be repeated whenever they again become aggravated. This variety of keratitis leaves a characteristic scar, which tends to clear away slowly in the course of time, though it rarely disappears entirely.

Clear corneal ulcers.—A clear form of ulceration of the cornea—that is to say, one in which neither the base nor the margins of the ulcer exhibit any infiltration—occurs almost exclusively in old enfeebled individuals, and is accompanied by little or no circumcorneal injection, and often by few, if any, subjective symptoms at all, beyond more or less interference with vision according to its site. The infiltration stage of this

FIG. 59.—Case showing an extensive superficial ulceration of the dendritic type.

type of ulcer is rapid, and therefore rarely observed; the healing stage is, on the other hand, very chronic. It is this circumstance which gives rise to the name *clear ulcer*. The *treatment* most likely to stimulate these ulcers to heal is the use of hot fomentations.

Marginal ring-shaped ulcer.—A long, narrow, ulcerated rill sometimes forms on the margin of the cornea, and extends in a ring-shaped manner round it. When occurring in children it is always caused by the confluence of a number of separate foci of inflammation. Such an origin, though probable, cannot always be demonstrated in the case of the less distinctly

strumous form which is met with in adults. The infiltration is seldom great, but this form of ulceration is accompanied by a good deal of circumcorneal injection and other symptoms of irritation. By extending completely round, the clear central portion of the cornea may be deprived of its source of nourishment to such an extent as to necrose. In severe cases, which are fortunately rare, complete loss of the cornea may be caused by this form of ulceration. The etiology is not always clear, but it often comes on in connection with some form of catarrhal conjunctivitis. The *treatment* should be directed towards preventing the spread of the ulcer. This is best done by paracentesis, which may be frequently repeated if necessary. Eserine and corrosive sublimate lotions are also useful. Occasionally it may be found advisable to use the actual cautery, followed by iodoform ointment.

Mooren's rodent ulcer.—This disease, though previously known, was first recognised as a definite type by Mooren. It is a rare affection, which, though in some respects like the *ulcus corneæ serpens*, is distinguished by being essentially chronic, lasting before complete cicatrisation for three or four months at least—not unfrequently for a year or more. It generally begins as a small superficial ulceration at some part of the cornea close to the corneo-scleral margin. In appearance it is so like catarrhal or eczematous ulcers that it cannot be distinguished from these. Yet there is in this form some inherent tendency to slow invasion of the cornea, both superficially and in depth, which presents much the clinical aspect of an epitheliomatous degeneration. The ulcer itself, owing to its slow progression no doubt, has mostly a clear base, except in parts which have undergone a sort of healing, and which are covered by imperfect epithelium and a few newly formed blood vessels. The margin separating the ulcer from the unimpaired cornea, and which represents the irregular line which superficial extension is taking, is occupied by a whitish overhanging area of débris, and is therefore opaque.

Progression is not as a rule continuous. Periods of partial healing or cessation of the process intermit with others in which the advance is more rapid and active. When untreated, or when the treatment adopted has failed to arrest the disease, the whole surface of the cornea, to a depth of a quarter or more of its thickness, becomes converted into cicatricial tissue, the density of which may diminish slowly in the course of time. Vision is thus greatly reduced, though apparently not often to the extent of causing practical blindness. Usually sufficient vision remains to enable the patient to guide himself. No cause is known for

this disease. It appears not to be due to the presence of any microbe.

The only *treatment* is the actual cautery. The chance of arresting the ulceration depends greatly upon the completeness with which the cautery is used. As in the case of the septic form of serpiginous ulcer, particular care must be taken to thoroughly burn through the tissues of the spreading margin. Mooren's ulcer is usually met with after the age of 40, though it may occur in younger individuals. In elderly people, whenever a superficial marginal corneal ulcer makes it appearance, unassociated with an evident conjunctivitis, it is advisable not to delay the use of the cautery long should it show any tendency not to heal. No harm can be done by cauterising at this stage, and the development of the rodent character may thus not unlikely be checked. It seems possible that this type of disease may in some individuals be the result of an irritation directly ascribable to the treatment adopted. Thus I have seen two cases which were greatly aggravated by the use of Pagenstecher's ointment.

Vesicular keratitis.—A number of varieties, more or less distinct in their clinical aspects, occur in which the surface of the cornea is raised up into vesicles, which may be small or large, and single or multiple.

One of the most interesting and distinct forms is that to which Hansen Grut has drawn attention—a *recurrent bullous keratitis*. This form only comes on after a superficial wound of considerable extent, and presents itself as a clear bulla, which cannot properly be seen except by oblique illumination, and which may occupy from one-eighth to one-half of the superficial extent of the cornea. The number of times that this condition may recur after a trauma, as well as the length of the interval between each attack, is subject to considerable difference. It is not uncommon to find a recurrence take place from three to six times a year for several years. The attacks invariably come on in the morning on waking, with circumcorneal injection, considerable, often intense, pain, and the sensation as if there were a foreign body in the eye. Under these circumstances, and with a previous history of an external abrasion of the cornea, followed by the same kind of pain, there is always to be found a corneal bulla. Sometimes, indeed, this cannot be seen without pressing the lid against the cornea, the epithelium of which is then thrown into a fold, or by catching hold of the anterior epithelial surface of the separated layer with an iris forceps, when it readily comes away. Only very rarely is the

liquid contained in the bulla other than completely transparent. When yellowish or purulent some opacity is left, otherwise complete restitution takes place, so that the cornea becomes to all appearance absolutely healthy. A large superficial abrasion is very frequently followed by this form of inflammation, and, on the other hand, its occurrence at once leads one to the diagnosis, before the history of the original injury has been elicited. This, too, on account of the severity of the injury, there is very rarely any difficulty in obtaining. A cure takes place generally in from three to five days, except in the cases where the bulla is discoloured.

One of the most common causes of this affection is a scrape from a child's nail, and probably on this account, more than on any other, it is more frequently met with in women than in men. Other injuries, such as blows from branches or the end of an umbrella, may set up the same train of symptoms. The cause of the tendency to recurrence appears to be imperfect healing. The epithelium which replaces that removed at the time of the accident is more liable to injury, so that after a time the slightest rub, which may take place during sleep, will cause it to be detached in the shape of a bulla.

The *treatment* consists in removing the detached epithelium with a pair of iris forceps, and applying cocaine frequently to allay the pain, using at the same time some simple weak antiseptic lotion for bathing the eyes. The eye should then be tied up. There appears to be no way in which the recurrence can be prevented.

Another bullous form of keratitis, in which the bulla is not pellucid, occurs in cases of chronic inflammation of the eye, where there is or has been increase of intra-ocular tension. It is most frequently met with in old cases of glaucoma or irido-choroiditis, where the disease has led to complete, or almost complete, blindness. The bulla in these cases is due to an œdema of the cornea, which has led to the formation of a fibrinous false membrane between the epithelial cells and Bowman's membrane: it is this membrane, in addition to the epithelial cells, which forms the anterior wall of the vesicle. No treatment is called for in such cases, which are more of the nature of degenerative changes than of inflammation.

Secondary keratitis.—One form of secondary infiltration of the cornea is of very common occurrence, what is usually known as *interstitial keratitis*. This never leads to any ulceration of the cornea. It produces a very characteristic appearance, beginning as a diffuse greyish and tolerably deep-seated opacity,

which generally stretches in from some portion of the periphery of the cornea. The whole cornea may become pretty uniformly

FIG. 60.—From a case of non-vascularised interstitial keratitis—later stage at which the infiltration is confined to central portion of cornea.

infiltrated, while at the same time there is a very definite stippling of its epithelial surface. Not infrequently different

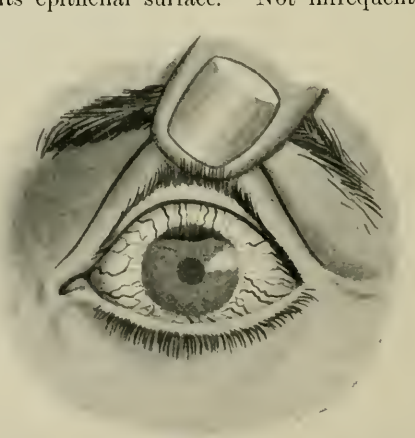


FIG. 61.—From a case of diffuse interstitial keratitis with dense vascularisation at upper margin of cornea.

portions of the cornea are more densely infiltrated than others, or there may even be a very distinct punctiform arrangement of

the infiltration, but there is never any prominence at such points as is seen in cases of primary infiltration. According to the density of the infiltration, the colour which it assumes is either white, grey, or yellow. When very dense it would be impossible, indeed, from the colour alone to say that no abscess was present. The degree of irritation is very variable, both in different cases as well as at different stages in the same case. There is usually circumcorneal injection, with photophobia and lachrymation, and often a more or less dense formation of new vessels in the cornea, giving rise to an appearance which has been called the "salmon-coloured patch." These vessels spring

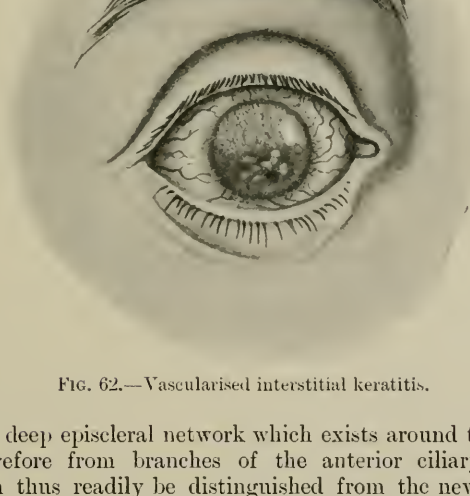


Fig. 62.—Vascularised interstitial keratitis.

from the deep episcleral network which exists around the cornea, and therefore from branches of the anterior ciliary arteries. They can thus readily be distinguished from the newly formed vessels of a pannus, which spring from superficial conjunctival trunks. As the intransparency clears away, the new vessels, as well as the other symptoms of inflammation, gradually disappear. As a rule, the central portions of the cornea are the last to clear up. Both eyes are usually attacked by this inflammation, though rarely exactly at the same time; more commonly the disease is pretty far advanced in one eye before the symptoms make their appearance in the other.

Interstitial keratitis always lasts a long time—three to ten

months as a rule. In some cases the duration is much longer. There is a great tendency for the iris to become inflamed at the same time, and there are also observable in most cases changes in intra-ocular tension—at first generally an increase, but afterwards, and continuing longer, a diminution, which is sometimes very marked. These circumstances, taken in connection with the absence of ulceration which characterises interstitial keratitis, sufficiently show that the disease is in reality not a true inflammation of the cornea itself, but merely an extension to it of inflammatory products derived from a focus of inflammation in the anterior portion of the uveal tract.

The age at which the disease most frequently shows itself is from 7 to 21. Individuals who are of delicate constitution from any cause are subject to it. The most frequent predisposing cause appears to be inherited syphilis, as it is often met with in individuals in whom there exist other manifestations of this disease, such as scars round the mouth, prominent frontal eminences, etc.

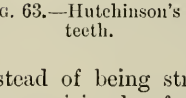


Fig. 63.—Hutchinson's teeth.

A very common condition, too, in the subjects of secondary interstitial keratitis, is a peculiar state of the incisor teeth, to which attention was first called by Hutchinson, by whom it is also considered a manifestation of inherited syphilis. The cutting edge of the tooth, instead of being straight, is arched or notched in a more or less semicircular form, the sides being longer than the centre (Fig. 63). Sometimes the form has not become definitely established at the time of examination, but there is often to be seen an indication that the cutting edge of the incisors is thinner than in the normal condition, and at the same time devoid of enamel. It is the wearing away of this portion which gives rise eventually to the characteristic notch.

Another complication is deafness, which appears in part due to a similar interstitial inflammation of the tympanic membrane, and in part to a periostitis within the channel for the auditory nerve, which probably causes the nerve to become involved in the inflammation.

In severe cases more diffuse choroiditis, as well as staphylomatous protusions of the anterior part of the choroid and the ciliary region of the eye, occur.

When the corneal opacity is very dense, it may sometimes not be very easy to ascertain whether or not any serious complication exists. As a general rule, it is not difficult, after a little practice,

to satisfy one's-self as to whether the visual acuity answers to the opacity or not. Even the very densest corneal infiltration produced by this disease should permit of the movements of the hand being seen close to the eye, so that if vision is further reduced there is certainly some complication present. In uncomplicated cases, too, the field of vision is of course of normal extent.

In a large majority of cases of interstitial keratitis the opacity eventually clears up entirely, or leaves but the faintest trace, discernible only on oblique illumination. Although no ulceration takes place, there may occasionally be a kind of necrosis of the cornea (keratomalacia), leading to perforation. The *prognosis* depends, in fact, on the severity of the primary affection. When the iritis is slight, and no choroiditis or staphylomatous protrusions make their appearance, it is good, even though the opacity should be at one time extremely dense. Occasionally cases beginning as interstitial keratitis go on slowly to shrinking of the eye. Sometimes two or more attacks may occur in the same individual at considerable intervals of time.

The disease runs a definite course, and it is very doubtful, just as in the case of other deeper uveal affections, how far any *treatment* is of any avail. The eyes should certainly be protected from strong light by means of dark glasses, and the patient not allowed to read. When there is much circumcorneal injection the pupil should be kept dilated with atropine, so as to avoid the worst consequences of a complication with iritis. Attention to the skin and to the health generally, moderate exercise, and the use of syrup of the iodide of iron internally, either alone or combined with a little iodide of potassium, are indicated. In the distinctly syphilitic cases mercurial preparations may be tried. When ciliary staphylomata develop, it is advisable to try eserine, which appears to have some influence in preventing their extension. All surgical interference, even such a simple measure as paracentesis, should be avoided, except in cases where there is a marked shallowing of the anterior chamber. In these iridectomy should be performed as soon as possible.

Other less characteristic and altogether much less frequent forms of secondary keratitis are met with, in connection usually with old-standing cases of choroiditis and irido-choroiditis. In these the prognosis is relatively much worse than in what is usually known as interstitial keratitis, owing no doubt to there being less tendency towards the healing of the primary process on which they depend.

A few cases of interstitial keratitis afterwards become

associated with a tuberculous-looking deposit in the anterior chamber and iris, as well as a dense whitish opacity in the corresponding portion of the cornea. The affection is then extremely chronic, and is of a tuberculous nature, and allied to, though by no means the same affection as, granuloma of the iris. It is very probable that many of the less severe cases are also tuberculous.

Neuro-paralytic keratitis.—When the fifth nerve is paralysed there is a tendency for the cornea to become inflamed. Different forms of inflammation may occur under such circumstances, which all, however, exhibit, besides the accompanying anæsthesia, a marked slowness in healing, if indeed they do not lead to the total destruction of the cornea.

The main cause of so-called neuro-paralytic keratitis is the greater vulnerability of the cornea.

The *prognosis* in all cases of neuro-paralytic keratitis is necessarily bad.

The *treatment* consists in as far as possible protecting the eye from external influences, by keeping it tied up, and frequently applying antiseptic lotions. The corneal changes which are met with in herpes zoster frontalis may be looked upon as neuro-paralytic in their nature. In some cases a number of small herpetic blebs form on the cornea, very similar to those met with on the skin. These burst and leave infiltrated margins, and eventually more or less opacity. In other cases the first appearance in the cornea is of one or more infiltrations or ulcerations. The affected portions of the cornea are generally anæsthetic, and often remain so, long after healing has taken place. A corneal complication appears to be met with in about one-fourth of all the cases of herpes zoster frontalis. According to Hutchinson, the cornea is only affected when an eruption at the side of the nose indicates a participation of the naso-ciliary branch in the affection. This connection is certainly frequent, and in my own experience it has been invariable; but cases are on record where the cornea has been affected without the skin of the nose being implicated, while at the same time the skin of the nose has been found to be affected and not the cornea.

Non-Inflammatory and Degenerative Changes in the Cornea.

Transverse calcareous film.—A very curious form of corneal opacity occurs, mostly in eyes which are at the same time the site of some old-standing inflammatory changes, such as chronic iritis with occlusion of the pupil, and it may be, with calcareous

degeneration of a cataractous lens. This consists of a transverse film running across the cornea, always at that part which corresponds to the half-closed lids. It generally begins at the corneal margins, and spreads from both sides towards the centre. The breadth of the band is tolerably uniform throughout, being in different cases from about $\frac{1}{8}$ to $\frac{1}{6}$ inch. The opacity is finely punctiform, and varies in colour from a grey to a pretty pronounced yellowish brown. Examined with a magnifying-glass, it is found to be composed of a number of granules, which are very regularly distributed and of much the same size throughout. Its edges are very sharply defined, and do not anywhere merge into the healthy cornea. It is often least dense at the centre of

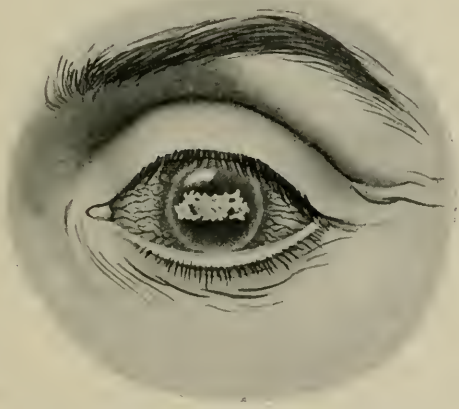


Fig. 64.—Transverse calcareous band of cornea.

the cornea over the pupil, but altogether much more intransparent than its appearance at any distance would lead one to suppose, owing probably to the calcareous degeneration which takes place in the deposited matter. There is rarely any disturbance of epithelium above the opacity.

This form of opacity almost invariably occurs in both eyes, though it may exist to a much more marked extent in the one than the other at the time of examination. It is met with at all ages and in both sexes. The opacity forms very slowly, and then remains for an indefinite time stationary. The surrounding cornea is as a rule perfectly healthy, but there is a variety of the same affection which makes its appearance in old-standing

leucomata. From the fact that some form of uveitis is almost always found to be associated with it, it seems probable that, even when the disease is apparently primarily a corneal one, there is nevertheless some deep-seated affection, which, though it may escape observation at the time, afterwards develops into something more manifest. Glaucoma is often met with, sooner or later, in connection with these calcareous films in the cornea. Any *treatment*, such as scraping away the film or removing it by means of very dilute nitric acid, is of very little permanent use, as it again develops.

Arcus senilis.—This is a whitish and generally eventually completely circular opacity, which extends round the margin of the cornea in old people. It begins at the upper and lower margins of the cornea, and varies considerably in thickness in different individuals as well as often at different parts of the cornea. Very often the arcus is separated from the scleral margin by a clear or less opaque strip of cornea. The appearance is due to fatty degeneration of corneal cells. Wounds through this area of degeneration heal much as in the normal cornea.

Conical cornea.—Owing to a thinning of the central portion of the cornea, a change of its curvature may take place, whereby the normal ellipsoidal form becomes converted into one more resembling a hyperboloid of revolution. The curvature of the central portion becomes greater, that of the peripheral portions less, than normal (see Fig. 65). This gives rise to myopia, and to a degree of irregular astigmatism with polyopia. The apex of the conical cornea always lies slightly below the centre, and is often more or less opaque. It may be so thin that it can be seen with the ophthalmoscope to pulsate synchronously with the pulse. The condition is amost invariably bilateral, though frequently not developed to the same extent in both eyes. The pathology is not known. The conical bulging begins generally after puberty, in the early years of adult life. It is not improbable that the degenerative change in the cornea may go on for some time before the bulging begins. There is a decided tendency for the condition to remain stationary after having progressed for some time. I have seen several cases where the condition has lasted for upwards of thirty years without destroying sight, or indeed rendering reading altogether impossible. Not infrequently, however, the protrusion gradually increases, and is associated with more and more opacity.

The *diagnosis* of conical cornea is made without difficulty by mere inspection when the protrusion is pronounced. The conical

shape can be readily seen by looking at the cornea from the side. When slight, or only beginning, it is diagnosed by means of the ophthalmoscope or Placido's disc. With the ophthalmoscope a peculiar circular-shaped shadow is thrown on the fundus, which alters its position with the movement of the mirror. It corresponds to a zone through which fewer rays pass to the observer's eye, owing to the rays on one side of the zone being convergent and on the other divergent as they emerge from the eye. With Placido's disc the great diminution in the size of the image of the rings on the apex, and their

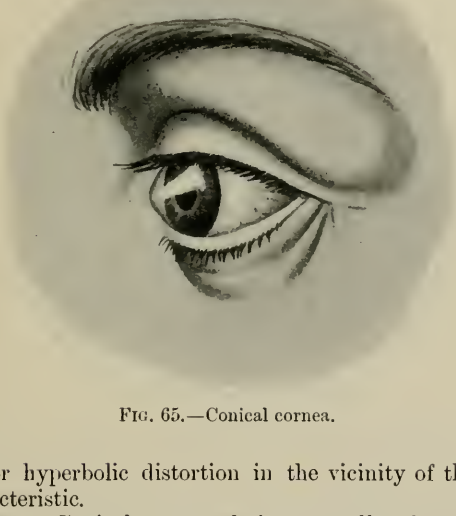


Fig. 65.—Conical cornea.

elliptical or hyperbolic distortion in the vicinity of the apex, is very characteristic.

Treatment.—Conical cornea admits generally of some, though rarely of very complete, optical correction. The higher numbers of negative spherical and cylindrical lenses, either separately or combined, are those which are most likely to prove of service. Sometimes a stenopaic aperture or slit may be added with advantage. In many cases the possible optical correction is so small that some operation is indicated. All operations which have been devised for conical cornea are more or less doubtful in their results. Removal of an elliptical portion from the apex, or from near the apex, of the cone has been recommended.

In suitable cases there is no better or simpler operation than

that of producing a nebula of the apex with the actual cautery. This nebula may afterwards be darkened by tattooing it with Indian ink. This proceeding always causes improvement in all cases in which vision is found to be better when a ring-shaped stenopaic aperture is held in front of the eye.

Another form of misshapen cornea is what is called *keratoglobus*. In this condition, which is not nearly so common as conical cornea, and probably always congenital, there is a more general thinning, and consequently a more globular distension, of the cornea. Examined with a Placido's keratoscope, there is little or no distortion of the circular rings. The cornea is sometimes so thin, that when paracentesis is performed it falls in,

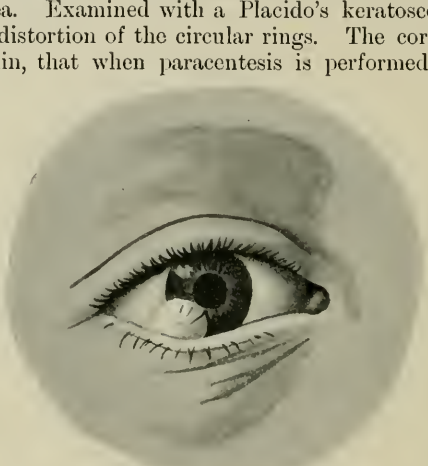


Fig. 66.—Dermoid cyst of cornea.

crumpled up like paper. No treatment is likely to be of much avail.

Tumours of the Cornea.

Dermoid cyst.—This may be found as a congenital growth at any part of the margin of the cornea. It seems usually to remain of much the same size during life, though occasionally found to increase after birth. The cyst is firmly attached to the cornea by half, or rather more than half, of its base, the other portion being attached to the episcleral connective tissue. A dermoid cyst of the cornea, owing to its position and size, seldom interferes with vision, but may require removal on account of producing more or less conjunctival irritation, or on account of its unsightly appearance.

Fibroma of the cornea.—This is a rare affection. It occurs as a flat growth of densely white appearance, involving the superficial portion of the cornea, over the whole of which it very slowly spreads. When met with before it has involved the whole cornea, it should be removed by slicing off layer after layer, until the transparent tissue below it is reached.

Malignant tumours of the cornea rarely occur primarily. They usually either involve the cornea by extension from the deeper tissues of the eye (ciliary body, choroid, etc.), or from the conjunctiva, in which case only the superficial layers of the cornea are implicated. The principal forms met with are sarcoma, generally of the melanotic type, and epithelioma. Owing

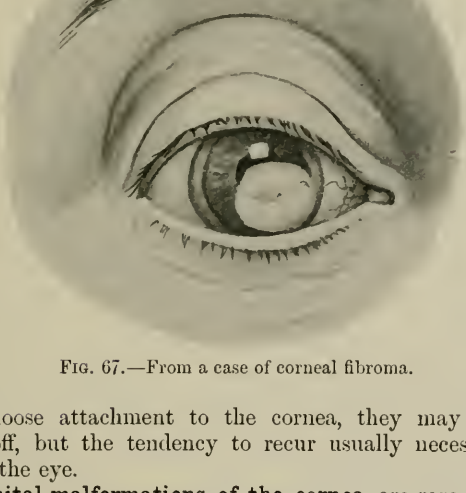


Fig. 67.—From a case of corneal fibroma.

to their loose attachment to the cornea, they may easily be scraped off, but the tendency to recur usually necessitates removal of the eye.

Congenital malformations of the cornea are rare, unless we include under such, corneal astigmatism. Sometimes the cornea is much smaller than normal, a condition known as *microcornea*; in others it is much too large—*macrocornea*. Both these deviations are most frequently accompaniments of more general deformities,—*microphthalmos* and *macrophthalmos* respectively,—though they may exist alone, or at all events constitute the most evident deformity. A congenital opacity of the cornea, either partial or complete, is also met with very rarely.

Injuries to the cornea.—Superficial abrasions of the cornea, which rarely involve more than the epithelium, are frequently met with. An injury of this nature may result from a scratch from the finger-nail, or from the eye being struck with some object,—*e.g.*, the branch of a tree, end of an umbrella, etc.,—or from the rubbing of some small foreign body which has remained for some time in the conjunctival sac. The corneal abrasion, owing to the irritation which it causes of the numerous delicate nerve fibrils, always gives rise to very considerable pain, often accompanied at the same time by the sensation as if a foreign body were present in the eye. When the abrasion is large it may be followed by a form of recurrent bullous keratitis (see page 164).

The pain is at once allayed by cocaine, and the *treatment* consists in using frequently some mild antiseptic wash, so as to avert any possible subsequent inoculation of the wounded cornea. The extent of a superficial abrasion of the cornea may be made very apparent by dropping a drop or two of a half per cent. solution of fluorescine into the conjunctival sac, and washing away the excess with water. The area of the abrasion is thereby coloured a vivid green, while the rest of the cornea on which the epithelium is intact remains uncoloured.

Wounds of the cornea are frequent. They may be caused by cutting bodies, directly, or by severe blows. In the latter case a rupture usually takes place, not of the cornea itself, but of the globe, at or near the corneo-scleral margin, and roughly concentric with it. Direct injuries to the cornea may or may not cause perforation. The latter are of course on the whole the more serious. In both cases, however, a good deal depends on the nature of the body with which the injury has been inflicted. It is well, therefore, always to get as trustworthy an account of the accident as possible. Curiously enough, this is sometimes not easy, as either the patient himself or his friends not unfrequently try to conceal the circumstances of what they feel was an avoidable accident.

I have seen the cornea more or less seriously injured by almost every conceivable thing — knives, scissors, forks, hair-pins, needles, nails, glass, crockery, curling-tongs, bits of metal of all kinds, animals' teeth, claws, horns, children's nails, bits of wood, and many others. The first consideration will then necessarily be, was the substance likely to be clean, from a surgical point of view, or not? A wound may be comparatively trifling in itself,—merely, it may be, amounting to a slight epithelial loss,—but septic matter may have been introduced, and

unless antiseptic precautions have been taken in time, serious consequences may result. Much depends also, of course, on the state of the conjunctiva and mucous membrane lining the lachrymal sac. In the more superficial wounds of the cornea, it is a good plan, in addition to using antiseptic bathings, to clear away any epithelium which may have been destroyed, though not shed, in the vicinity, thus leaving a clean surface. After efficient bathing, the wound may be dusted with iodoform and the eye bandaged.

In deeper non-penetrating wounds, the more or less complete adaptation of the lips makes it difficult to disinfect properly. In such cases, the proper thing to do is to treat the case at first in the same manner as if it were quite superficial, but keep the patient under observation for a day or two, in case any decided evidence of a septic inoculation should show itself, when it is necessary to destroy the area of the wound with the thermo- or other cautery. Even at first, when the history of such an accident shows that it was caused by a dirty instrument, it is well to disinfect as actively as possible, using for this purpose chlorine water applied with a camel's-hair brush.

Perforating wounds of the cornea do more or less harm, altogether independently of the question of whether septic matter has been introduced into the eye or not, according to their site, shape, and extent. Small clean-cut wounds, made by some sufficiently aseptic body, heal very rapidly and leave little scar, if they are linear and not too oblique. The apposition of the lips of the wound is then good, and ordinary antiseptic precautions, and tying up the eye for a couple of days, is all that will be required in the way of treatment. If, in addition, they lie beyond the pupillary area of the cornea, the prognosis as regards vision is good, always supposing that the lens has not been injured at the same time. Larger linear wounds, even if they are got to heal without any prolapse of iris taking place through them, always leave some defect. The defect is greatest if they are central, and is caused not only by the cicatrix, which, under favourable conditions of healing, may be astonishingly slight, but by alterations of curvature, which become permanently established in the pupillary area of the cornea—irregular astigmatism. The treatment of prolapse of iris is elsewhere discussed. With regard to wounds, however, it must be remembered that, inasmuch as they are more likely to come under observation shortly after their occurrence, it is more often possible to replace the prolapse. The thing to aim at in the treatment is to get good apposition of the lips of the wound;

and the usual point which will have to be considered in any case is, as to whether this shall be got by replacing the prolapsed iris or by removing it. The decision on this point should be influenced by the degree of injury which the prolapsed iris has suffered, as well as by the nature of the body, in regard to probable asepticity, which has caused the accident. Further, when attempts are made to reduce the hernia, a good deal must depend upon the ease with which this can be done. In clean-cut wounds, especially linear wounds made with a clean instrument, or in cases in which the cornea has burst without anything having come directly in contact with it, it is justifiable and generally easy enough to replace the iris. In dirty, ragged, irregular-shaped wounds, on the other hand, the prolapsed iris must be sacrificed, or, if the case be seen some days after the accident, left, and removed later in the manner already referred to.

Small particles of dust, coal, or metal, and husks of grain, are very liable to become embedded in the cornea. The distance to which they enter depends on their size and shape, and the force with which they are driven against the eye. In most cases the foreign body lies superficially in the corneal epithelium. In the case of small portions of metal it very often happens that the cornea is not only wounded, but at the same time slightly burnt, owing to the piece of metal being hot at the time it strikes the eye. These, which are popularly called "fires," differ from other foreign bodies by being as a rule less firmly embedded, owing to the destruction of the immediately surrounding tissue. A brownish ring is often left, too, after their removal, partly an eschar and partly rust, which, if not scraped away, is some days in falling off. Usually a foreign body gives rise to sudden pain when it lodges in the cornea, and often more or less pain remains until it is removed. The pain is more especially complained of on movement of the lids over the cornea. Except, too, in the case of smooth and chemically non-irritating substances, the eye becomes rapidly injected, and the patient suffers from photophobia and lachrymation. Husks of grain become embedded with their concave surfaces towards the cornea, and the lid passing over their smooth surfaces does not give rise to much pain.

The first point to attend to in removing bodies from the cornea is to use an aseptic instrument. The best form of instrument to use is a corneal spud, either smooth or, preferably, grooved. But any sharp-pointed knife will do, and in the case of deep-lying foreign bodies may even be more suitable.

Another point to be attended to is to take care to avoid scraping away any more of the corneal epithelium than necessary. The spud or other instrument must, of course, be dug in as far as is required to remove the foreign body. But one's attention must be confined to the one place at which the body is lodged. Too much scraping about in the vicinity must be avoided. To work with the least risk of unnecessary scraping, the patient's head and eye must be properly fixed. The best way to do this is to seat him on a chair facing a good light, or, if the operation is performed after dark, in such a way that an assistant is able with a convex lens to concentrate a beam of candle or gas light on the cornea. Then, standing behind him, with his head leaning against the operator's chest, the lids are held apart with the fore and middle fingers of the left hand. These fingers should be pressed against the *margins* of the lids, otherwise it is not possible to counteract properly any efforts that the patient may make to close his eye. At the same time, by slight pressure of their points on the globe itself, above and below the cornea, one may sufficiently control its movements. Cocaine renders it possible to remove foreign bodies without causing pain, and also generally ensures steadiness on the part of the patient, so that it is seldom that any particular skill is required in the operator to enable him to confine his attention to the foreign body, and not wound any other part of the cornea. The main difficulties, when the precautions mentioned have been taken, are associated with the removal of deep-lying bodies. Sharp, irregularly-shaped small pieces of stone or metal often lie deeply embedded, and in a track which passes obliquely into the corneal substance. There is some danger of pushing such bodies through into the anterior chamber. A sharp-cutting fine knife or needle should be used to open up the track well before any attempt is made to push a spud in behind the body.

FIG. 68.—Corneal spud.

The subsequent treatment of a case in which a foreign body has been removed from the cornea should depend upon the depth and appearance of the wound which is left. In the majority of cases, taken in time, all that is required is to keep the eye

clean for twenty-four hours with boracic acid lotion. Other cases may have to be treated on the lines already laid down in connection with corneal wounds.

Deposits in the cornea.—Some metallic salts, used in solution as lotions for the eye, may leave deposits in the cornea. This danger is greatest with lead lotions, which should never be used where the cornea is inflamed. A white deposit of lead is very rapidly formed on the surface of a corneal ulcer, and may often occasion much greater defect of vision than would arise from simple cicatrisation. As such lead deposits are generally superficial, some improvement may result from scraping them away. Nitrate of silver, in the same way, may lead to an opacity, but this is not nearly so unsightly, being a deposit of a number of more or less closely packed brownish or black dots. A much more prolonged use of this substance is required, too, to produce much staining, than is the case with lead lotions.

Sclero-corneal ruptures.—When the coats of the eye are ruptured by a severe blow, the line of rupture is most frequently roughly concentric with the margin of the cornea, and from 1 to 2 mm. distant from it. The eye, in fact, gives way close to the true corneo-scleral junction at the angle of the anterior chamber. Such ruptures are usually in the upper portion of the corneo-scleral junction, but may be in any part of it. They rarely involve the ciliary body. When large they may permit of the escape of the lens, and it is in this way that a subconjunctival dislocation of the lens takes place (see p. 231). The vitreous, too, and even the retina, may be propelled through an extensive rupture of this nature. A less extensive wound generally gives rise to quite a characteristic appearance; a portion of the iris becomes prolapsed into it, so that the centre of the pupil is drawn to the wound, and an apparent coloboma results. The conjunctiva which remains intact is often raised, too, in the form of a bleb over the wound, by aqueous humour infiltrated below it, and the escape of aqueous in this manner leads to a marked shallowing or abolition of the anterior chamber.

Owing, no doubt, to the integrity, as a general rule, of the conjunctiva, corneo-scleral ruptures are rarely followed by severe inflammation. On the other hand, they seldom heal without leaving a great deformity. This is due to the separation of the lips of the wound by prolapsed iris, etc. On this account they usually call for operative *treatment*. In fresh cases an opening should be made in the conjunctiva a quarter of an inch or so behind the rupture, and parallel with it. The conjunctiva should

then be undermined, so as to form a flap, which can be lifted away from the wound. When this has been done, the prolapsed iris is removed as completely as possible, so as to admit of the edges of the wound coming in contact. The conjunctiva can then be carefully stitched over the wound. There is rarely any use trying to replace the prolapsed iris, as it is generally lacerated as well. In cases which have been allowed to heal after the accident, and which have resulted in great deformity and corresponding interference with vision, a method of operating advocated by Nuël would seem to offer the best chance of improvement. It consists in making a section with a narrow knife, reopening the scleral wound, and then drawing the surrounding conjunctiva over this opening by means of a special suture. The object of the operation is to cover the wound with as thick a layer of superficial tissue as possible, and thus permit of the proper re-establishment of the anterior chamber. To effect this the knife, after cutting through the deep cicatricial tissue filling up the space between the lips of the wound in the sclera, is directed backwards, so as to cut out a deep flap of conjunctiva. A conjunctival suture is then introduced in the following manner: It is entered at the equator of the eye, as far back as possible, and passed out and in, or run through the conjunctiva for a considerable distance, parallel with the corneo-scleral margin. The needle is then carried diagonally over to the conjunctiva immediately surrounding the cornea at the opposite end of the wound, and the thread run in a similar manner close to the cornea, and finally brought out beyond the wound at the other side. The two ends of the thread are then tied tightly together. In this way a large mass of conjunctiva is puckered up over the wound, in a much more efficient manner than could be done by the introduction of a number of sutures in the ordinary way.

Operations for corneal staphyloma.—When a partial staphyloma of the cornea becomes unsightly, it may be reduced in size by the following simple operation. A cataract needle is introduced through its base, and held in one hand. An elliptical piece of the cicatricial tissue of which the staphyloma is composed is then cut out by making one incision at the one side of the needle with a narrow cataract knife, and another from the other side converging towards the first, and in such a manner that the portion held by the needle, and consequently the needle itself, is cut out. This can be done very quickly. Antiseptic precautions should be taken and a firm bandage applied.

In cases of more complete staphyloma, attempts have been made to retain a better stump by covering up the wound result-

ing from the removal of the protruding cicatricial tissue which takes the place of the cornea. Inasmuch, however, as, if inflammation be set up, there is considerable risk of sympathetic ophthalmitis, it is rarely advisable to attempt an operation of this kind. Critchett was the first to recognise the importance of closing up the wound, and this he did by inserting a number of deep stitches through the sclera before removing the staphyloma. The needles were entered through the sclera above the protrusion, carried underneath it, and brought out again through the sclera below it. The sutures could then be drawn through and tied as soon as the corneal cicatricial tissue was removed. This method of operating was afterwards modified by Knapp, who used conjunctival sutures instead of scleral ones. More recently the following operation has been recommended by Wecker, and is probably the best of its kind. Before removing the staphylomatous protrusion, the conjunctiva and subconjunctival tissue

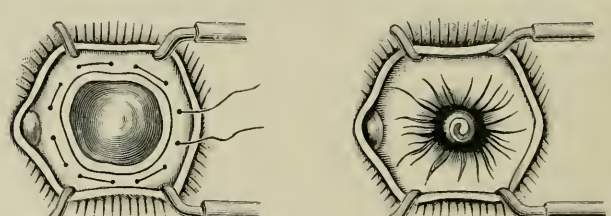


Fig. 69.—After Wecker.

surrounding the cornea is freely undermined for some distance. A strong suture is then run through this loosened tissue at a distance of a quarter of an inch or so from the corneal margin, and with not more than a quarter of an inch intervening between each puncture made by the needle until the other end of the thread is brought out near to the first puncture. The protrusion is then cut off by transfixing it through the middle, and cutting outwards, then seizing the end of the flap thus formed and removing the rest with scissors. As soon as this has been done, the two ends of the continuous suture are drawn together and firmly knotted (see Fig. 69). The effect of this is to draw the conjunctiva over the wound, and thus prevent the escape of the vitreous; the lens generally escapes with the removal of the protrusion; if it does not, the capsule may be scratched so as to permit of its escape. It is of the utmost importance that antiseptic precautions should be taken in this operation. The thread may be allowed to remain for a week at least. If it cuts

through at any part, a fresh stitch may be used for bringing the conjunctiva together where this takes place.

The most suitable operation for cases of complete staphyloma is evisceration of the globe.

Tattooing of the cornea.—This may be done either with the object of removing the unsightly appearance of a dense leucoma, or to improve vision. In the latter case it may or may not be combined with iridectomy according as the whole pupillary area is covered or not by the cicatrix.

Central nebulæ which do not entirely cover the pupil may, nevertheless, cause considerable visual disturbance by scattering the light which passes through them into the eye. By blackening a nebula with Chinese ink this disturbance is in great measure removed. The same advantage may be got by tattooing when, whilst some clear cornea remains, a nebula is sufficiently extensive to call for a displacement of the pupil by iridectomy. The rays which then pass through the artificial pupil are more effective when the scattered light has been stopped.

FULL SIZE
FIG. 70.

FULL SIZE
FIG. 71.

Tattooing may be done either with a single grooved needle (Fig. 70) or with a bundle of finer needles held together in a special holder (Fig. 71). Often it is useful to use both: beginning the blackening with the former inserted obliquely at points close to each other all round the area to be stained, and then continuing it by making several stabs with the latter instrument over the enclosed space. As thick a watery suspension of the ink as possible should be used. This is carried into the cicatricial tissue with each prick by the grooved needle, and dabbed on to the surface with a camel's-hair brush after the stabbing with the bundle of fine needles.

The operation is painless under cocaine, and seldom causes much subsequent irritation. It is, however, generally necessary to repeat the process once or twice, at intervals of a few days, before the desired degree of blackening is obtained. It is important to remember that the eye must be steadied only with the finger tips, not fixed with the forceps, as the ink getting into the wound in the conjunctiva made by the teeth would leave a stain there.

Scleritis. — Inflammation of the sclera is confined to its

anterior part, which is covered by conjunctiva. Scleritis may occur in circumscribed patches, or may be diffused in the shape of a belt round the cornea. The former is usually more superficial and uncomplicated, the latter deeper and complicated with corneal infiltration, irido-cyclitis, and anterior choroiditis. It is common to distinguish the superficial cases of inflammation as cases of *episcleritis*. This, though a useful clinical distinction, cannot always be made, as the superficial inflammations pass by insensible gradations into the deep forms, to which the name *scleritis* is more generally applied.

Superficial scleritis, or episcleritis, is a long-continued disease which is associated with very varying degrees of discomfort. In

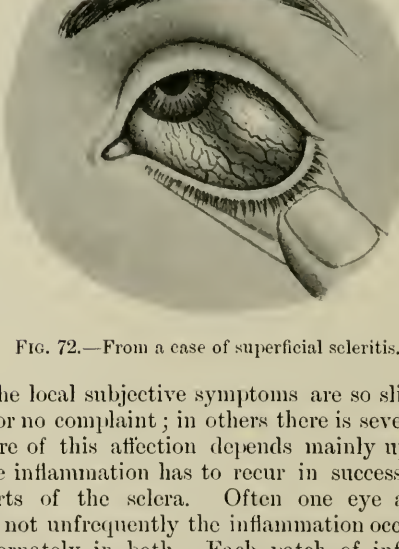


Fig. 72.—From a case of superficial scleritis.

some cases the local subjective symptoms are so slight as to give rise to little or no complaint; in others there is severe pain. The chronic nature of this affection depends mainly upon the tendency that the inflammation has to recur in successive patches at different parts of the sclera. Often one eye alone may be affected, but not unfrequently the inflammation occurs simultaneously or alternately in both. Each patch of infiltration lasts for a month or two, and is succeeded by another, or it may be two at the same time, after an interval of varying duration. In most cases several months, or even years, elapse between the attacks. In others, again, patch upon patch makes its appearance as soon as a preceding one has disappeared, or even before it is completely removed. The new patches almost invariably appear at

some new point, the cicatricial site of a previous patch not being again attacked. The actual patches vary in size, being usually somewhere between a quarter and a half of the diameter of the cornea across, and approximately circular. The scleral infiltration causes a firm swelling, which is often sensitive to touch, and over which the conjunctiva is freely movable. The overlying conjunctiva is always injected, and the area of its injection is greater, sometimes much greater, than that of the scleral infiltration. The infiltration is itself, at the height of the process,

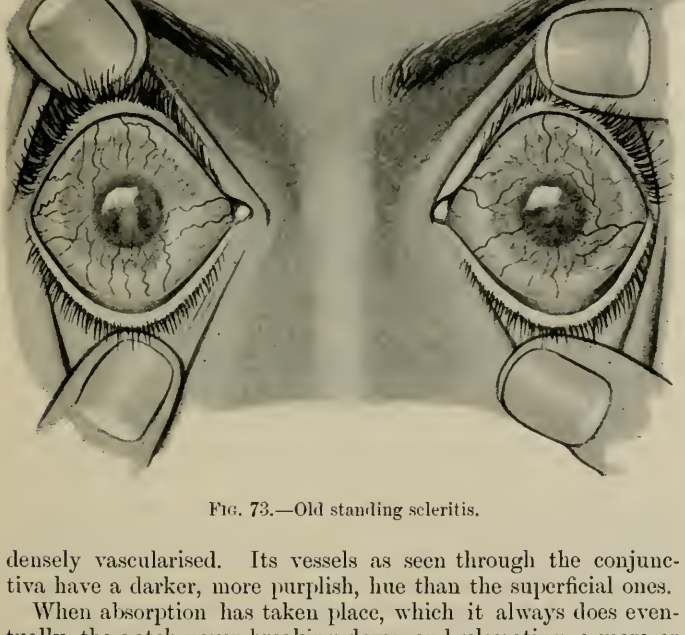


Fig. 73.—Old standing scleritis.

densely vascularised. Its vessels as seen through the conjunctiva have a darker, more purplish, hue than the superficial ones.

When absorption has taken place, which it always does eventually, the patch never breaking down and ulcerating, a more or less definite alteration is left at the spot occupied by the infiltration nodule. The swelling caused by the infiltration, which in many cases may be most pronounced, gradually subsides, leaving a cicatrix, to which the overlying conjunctiva becomes adherent. The site of this cicatrix, as seen through the conjunctiva, has always a more or less slaty-looking colour, described sometimes as porcellaneous-looking. Owing to patches of this kind being

left, it is seldom difficult to recognise a case in which there has at one time been an attack of superficial scleritis.

Episcleritis patches, which are situated fairly close up to the margin of the cornea, might possibly be mistaken for hyperplastic conjunctivitis (spring catarrh), or for a focus of phlyctenular conjunctivitis. The differential diagnosis presents little difficulty, however. Scleritis patches are never found quite at the corneo-scleral margin, as in the case of the hyperplastic tissue of spring catarrh. Besides, the conjunctiva is movable over the patch; while, in contradistinction to the phlyctenular type of inflammation, they never break down and ulcerate. The only exception to this occurs in cases in which the scleral patches are tuberculous.

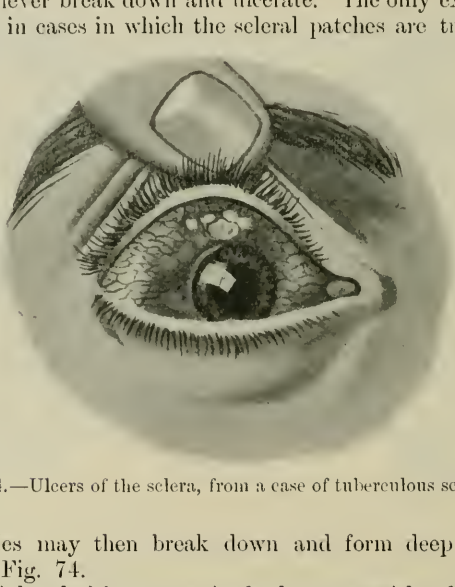


Fig. 74.—Ulcers of the sclera, from a case of tuberculous scleritis.

The nodules may then break down and form deep ulcers, as shown in Fig. 74.

Superficial scleritis occurs in both sexes with about equal frequency. There is no known definite cause for this disease. The individuals affected are generally middle-aged. They are often rheumatic, and sometimes gouty. But in how far these conditions are mere accidental concomitants, or are of any real causal significance, is not by any means certain.

The *treatment* is on the whole unsatisfactory. Some recommend large doses of the iodides; others believe that subcutaneous injections of pilocarpine do good. My own experience of both these remedies has not been particularly encouraging. Subconjunctival injections of corrosive sublimate solutions into the

scleral infiltrations have been vaunted in some quarters. Any action that they may have appears to me to be due entirely to the mechanical dispersion which the liquid may effect. I have in some few cases used them, but have got equally good effects with the injection of sterilised water, which has the advantage of being much less painful. Massage has also been employed, and is undoubtedly useful. The area of swelling is rubbed through the lid for half a minute or so at a time two or three times daily. This seems to help in the dispersion, and promotes the absorption of the infiltration, and may even be combined under cocaine with the sterilised-water injections. I have also tried incising the patches and scraping with a small Volkmann's spoon. But the treatment which has yielded me the best results, and which I now adopt in all cases, is free cauterisation of the infiltrated nodules with the thermo-cautery. This seems not seldom to cut short an attack.

FIG. 75.—Small Volkmann's spoon, used for removing corneal and scleral infiltrations.

After recovery from one attack, salicylate of soda may be tried, and continued for some time. Baths seem also to do good in preventing recurrence. Harrogate, Buxton, Homburg, and Wiesbaden are those of which I have most experience in this connection. Wiesbaden has on the whole given the best results.

Deeper scleritis, with its attendant complications, is altogether a more serious disease. Etiologically it is just as obscure as the more superficial affection. Both eyes are almost invariably attacked in the typically deeper-seated inflammation. It is therefore not unlikely that the disease may stand in close relation to tuberculosis and inherited syphilis, which are often found to coexist in those suffering from it. In causation it would appear as if it were closely allied to the usual form of interstitial keratitis. It more generally occurs in young people: mostly in young women. In them it is undoubtedly frequently associated with menstrual disturbances, as well as with definite uterine and other complaints, which call for special attention.

Deep scleritis is more persistent than episcleritis. In it there are not such marked periods of intermission. The deeper and more wide-spread inflammatory infiltrations of the sclera lead eventually to weakening of that coat, and cause it to yield to

the intra-ocular pressure. There is thus formed a staphyloma of the sclera, in, or in the neighbourhood of, the ciliary region. The vision suffers from an infiltration of the cornea, by extension from the focus or foci in the sclera, or by iritis, with its attendant sequelæ, and anterior choroiditis, the so-called *sclero-choroiditis anterior*. Often these different complications exist together. In cases which have lasted for a long time they almost invariably do. In addition, the intra-ocular tension may increase (secondary glaucoma), and vision may in this way be altogether destroyed. The infiltration which invades the cornea does not clear away, but causes a dense porcellaneous white intransparency, to which the name of *sclerotising keratitis* is sometimes given.

Fortunately deep scleritis is very much less common than episcleritis, as its *treatment* is even more unsatisfactory and often well-nigh hopeless. Apart from the local treatment which may be required for coexisting uterine and other disorders, and from the exhibition of drugs from which little is to be expected, iridectomy should usually be tried. I believe it is of advantage to perform iridectomy early in the course of this disease. Iridectomy may certainly cause a retardation of the process, or may at all events delay the worst consequences of the more severe complications. If only resorted to, as some recommend, after the sclera has yielded and become staphylomatous, it is less likely to be of use. In cases which first present themselves at this stage, sclerotomy is a safer and more suitable operation.

CHAPTER VII.

DISEASES OF THE CRYSTALLINE LENS.

Several changes take place in the lens during life. In the young it is perfectly colourless; later on in life it is yellowish. The change in *colour* is accompanied by an alteration in *consistency*, bringing with it a diminution of elasticity, which is the cause of the gradually diminishing amplitude of accommodation met with as age advances. The *shape* of the lens is much more globular in infancy and childhood; the increase which takes place is therefore mainly at the equator. In this way, too, the dioptric value of the lens accommodates itself to the change which takes place in the length of the eye as it increases in size.

The *growth* of the lens (which, being derived from the cuticular epiblast, is analogous to that of the cuticle) goes on throughout life, and does not cease with the attainment of adult life. From 25 to 65 its weight and volume are increased by one-third, and its diameter by one-tenth.

The fibres are arranged in lamellæ, and towards the centre of the lens are more compressed than the superficial ones, and contain less water, but never any keratine. There is a gradual increase in the density, and consequently in the *refractive index*, of the different lamellæ passing from the surface to the centre of the lens. This difference becomes less marked, as age advances, by the gradual development of a hard central portion, the so-called *nucleus*, which becomes apparent about the time, or shortly after the period, of full growth, and slowly invades the more superficial portions of the lens, the refractive index of which, corresponding to the greater density, is increased. The refractive index of the superficial fibres of the lens differs but slightly in the eyes of young individuals from that of the aqueous humour. The increase in their refracting power, which comes on with age, brings about, however, a considerable difference. The reflection of light from the surface of the lens in old people,

which this abrupt change in refractive power admits of, is the cause of the greyish and semi-opaque appearance of the pupil which is so frequently observed.

The capsule of the lens is a highly elastic, and to all appearance homogeneous, membrane, which attains its greatest thickness at the anterior portion. While the lens fibres are known to be histogenetically epithelial, it still remains doubtful whether the capsule is originally an epithelial or a connective tissue. The latest investigations indeed seem to point to a double origin. The anterior portion of the capsule—what is usually spoken of as the *anterior capsule*—is covered on its internal surface by a single layer of epithelial cells, which play an important part in the physiology of the lens.

The normal *position* of the lens is that in which it is suspended at an equal distance all round from the circular ciliary body, so that its axis is nearly, if not absolutely, centred with that of the cornea. The centre of the anterior surface lies in the same plane as the iris, while the equator, owing to the curvature of the surface, is considerably behind that plane. A space is therefore left between the posterior surface of the iris and the anterior surface of the lens. This is the so-called *posterior aqueous chamber*. The suspensory ligament of the lens, or *zonule of Zinn*, has an extensive attachment to the processes of the ciliary body. Behind the zonule of Zinn, and between it and the vitreous, or more correctly between the fibres of the zonule which pass to the anterior and those which pass to the posterior capsule, is a space called the *canal of Petit*. The intimate structural as well as anatomical connections which exist between the suspensory ligament and the vitreous and anterior portion of the uveal tract, render a participation of that structure in deep-seated diseases of the eye not infrequent.

Cataract.—When the lens, which in its physiological state is transparent, becomes intransparent, there is said to be cataract. The loss of transparency may involve the whole or only a portion or portions of the lens, *i.e.*, the cataract may be *complete* or *partial*.

Anatomically, we may distinguish two forms of cataract—(1) *Lenticular* cataract; (2) *capsular* cataract. The first form is a result of the intransparency of the lens fibres or true lens substance, the second of the cells lining the capsule of the lens. The two forms may exist together or separately.

Clinically, cases of cataract may be grouped with advantage under the following heads:—(1) *Senile* cataract, which is due to an idiopathic degenerative change in the lens substance,

unconnected necessarily with any other condition which leads to an impairment of the functions of the eye; (2) *juvenile* and *congenital* cataract, of which there are various forms; (3) *complicated* or *secondary* cataract, in which the opacity of the lens is the result of more or less destructive changes in the deeper parts of the eye; (4) *traumatic* cataract; and (5) *after-cataract*, or the opacity which remains or becomes developed subsequently to the removal, by artificial or natural means, of the intransparent lens.

The transparency of the lens is only maintained when no great change takes place in its nutrition. A normal nutrition requires, as a rule, a normal position of the lens, and always integrity of its capsule. The main cause of intransparency appears to be a too rapid or irregular abstraction of liquid, which is favoured by some interference with the supply, or some abnormality in the constitution of the nutrient liquid.

It is only in eyes where no nucleus has yet formed in the lens, and therefore in the young, that the whole substance of the lens is capable of undergoing a degenerative change which leads to soft cataract. The nucleus may lose much of its transparency from sclerosis and increasing coloration, but it is not the same process of degeneration as takes place in the less altered portion of the lens.

Senile cataracts are of two kinds—*cortical* and *nuclear*. The former is much the more common. In this form only that portion of the lens which surrounds the nucleus becomes opaque. The colour of such cataracts, when the whole of this portion (the cortex of the lens) has become opaque, depends on the size and colour of the sclerosed nucleus, as well as on the degree of opacity of the cortical layers. When the opacity is dense and the nucleus small, a very uniform white appearance is met with; on the other hand, a greyish, and often yellowish, tinge is given to the cataract by the shining through of a large nucleus. In the first case, the cataract is comparatively *soft*; in the second, it is what is called *hard*. As a general rule, it may be taken that the older the individual is before the cataract begins, the larger is the sclerosed central portion, and the smaller the cortical opacity.

An abnormal degree of sclerosis may involve the whole lens, which in such cases is smaller than normal. This only occurs, as a rule, in very old people, and comes on very slowly. This form, in which no true cortical substance remains to undergo degenerative changes, and yet the sclerosed portion becomes greatly deprived of its transparency, is called *nuclear senile*

cataract. Often the lens is very darkly coloured, when the cataract is said to be "black." Nuclear cataract is therefore essentially a hard cataract.

Ordinary senile cataract, where there is a certain, though varying, proportion of cortical substance, begins apparently as the result of some irregularity in the process of sclerosis of the central portion. The first signs are to be seen in the region between nucleus and cortex. Variously shaped opacities, mostly radiating lines or striæ, which appear white by reflected and black by transmitted light, occur here; these gradually become confluent, and extend towards the capsule. This change is often associated with considerable increase in volume, so that the iris is pushed forwards and the anterior chamber shallowed.

When the whole cortex has become opaque, the cataract is said to be *ripe.* The term has reference to its then being capable of being shelled out of its capsule, to which it is otherwise somewhat adherent. There is considerable difference, however, in ripeness taken in this sense, as in some cases, even when the opacity extends right up to the capsule, the adhesion between lens substance and capsule is pretty firm, whereas in others again a semi-opaque lens separates very completely and readily from the capsule. It is not as a rule difficult to make out if the opacity reaches to the capsule or not; where there is any doubt, the diagnosis may be assisted by observing whether, when a light is held to one side of the cornea, the portion of the iris to the same side throws any shadow on the opaque lens; if it does, there must be an intervening portion of transparent lens. It must not be forgotten that a similar shadow may be seen in cases of over-ripe cataract. These cases may be diagnosed by observing that the anterior surface is at the same time flattened, whereas the unripe cataract presents a distinctly curved surface. Tremulousness of the iris—iridodonesis—is also frequently met with where the cataract is over-ripe and has undergone retrogressive changes.

After the condition of ripeness has existed for a longer or shorter time, further changes may take place, which are characterised as stages of over-ripeness. The opaque cortical substance may to some extent shrivel from loss of liquid, and in this way a little of the sight—as a rule, only a very little—be regained. On the other hand, and much less frequently, the cortex may become more liquid—to such an extent, indeed, that the nucleus moves about in it, and gravitates to the lowest point of the lens. Such liquid cataracts are called *Morgagnian.* The Morgagnian cataract is easily distinguished, too, by the position of the

yellow nucleus which has sunk to the bottom of the opacity. The diagnosis may often be made without dilating the pupil, by observing the difference in colour of the opacity when the patient is standing up or lying down. In the former case it is generally yellowish; in the latter milky white.

The time which elapses before a senile cataract becomes ripe varies within very wide limits. It is impossible in any particular case, as a rule, to predict even approximately how long the existing opacity will take to become complete. No regularity is shown in the process, which at times advances more rapidly than at others. Some cases, for instance, rapidly advance till a considerable degree of opacity is reached, and then only progress slowly to maturity; while others advance slowly at first, and, after reaching a certain stage, very quickly end in complete opacity. Probably, however, no cases remain absolutely stationary when once a separation has taken place between the nucleus and cortex, and striæ are seen beginning in the region between them. In cases where small opacities are found in other situations, there does appear to be some possibility of the condition remaining stationary—at all events for some considerable time.

The degree of blindness to which the progressing cataract gives rise depends a good deal on the site of the intransparent portions of the lens. If, for instance, as often happens, the cortical substance in the pupillary area is more affected than elsewhere, the vision is more seriously interfered with than where the same degree of opacity exists at another part of the cortex. In such cases vision is better in the shade than when the pupil is more contracted by a strong light, and a temporary benefit may be got by the use of a weak mydriatic. Less frequently, owing to the scattering of the light passing through the lens, or the polyopia which is produced by the formation of separate images by the different segments of the lens, vision is considerably improved under conditions which give rise to contraction of the pupil, so that some benefit is derived for a time by the use of a miotic or a stenopaic slit.

When a cataract is ripe, the vision is, as a rule, reduced to mere perception of light; but where the opacity of the lens is unaccompanied by any other affection of the eye, this perception is (except in the cases of extremely dense cataracts) very delicate. The simplest way of testing the light perception is to throw light reflected from a gas jet into the eye with the ophthalmoscope. The room should be darkened and the light be shaded from the patient. By turning the gas down or up it is

easy to determine the smallest amount of light which is just distinguishable from the light of the room. Another way which is often practised, and which affords, too, a means of readily comparing the acuity of the light perception in different cases, is to hold a lighted candle in front of the patient in a dark room, and notice whether he distinguishes between light and darkness when the flame is shaded by the hand or allowed to remain uncovered. Except in the very densest cataracts, the difference should be readily appreciated when the flame is from fifteen to twenty feet distant from the patient's eye.

A certain degree of refractive power always remains. The patient should therefore also be able, where there is no complication, to appreciate fairly well the direction from which light falls into the eye. This may be tested by asking him to point out the position of the flame of a candle, held in succession at different parts of the field of vision. A good *projection* indicates almost always not only a tolerably free field of vision, but also, as the patient directs his fovea to the light, an intact central vision.

This loss of all vision, with the exception of light perception, which characterises most cataracts which are ripe for operation, must not always be taken as the criterion of maturity. In some cases of hard cataract there is considerably more vision than this: the patient, for instance, being often able to count fingers close to the eye, so that if one were to wait for complete blindness before operating, much time would be lost to the patient. Fortunately, although senile cataract almost invariably affects both eyes, there is often a considerable time intervening between the time when maturity of the cataract is reached in each eye, so that if an operation be undertaken as soon as the first cataract is ripe, the patient is not rendered absolutely helpless by the disease. When both eyes are pretty equally affected at a stage when most useful vision is lost, an extraction may be undertaken rather sooner than would otherwise be done. Attempts at artificially ripening a senile cataract should not be made.

Sometimes the anterior capsule of the lens participates in the cataract; that is to say, the cells lining the inner surface of the capsule proliferate and lose their transparency. A *capsular cataract* is more especially met with in lenses which have become shrivelled and over-ripe. It is rare that the opacity extends beyond the limits of a moderately sized pupil. If the cataract be examined, with the pupil dilated, before an operation is undertaken, the capsular opacity cannot well escape detection.

It is intensely white, and frequently presents an irregular outline.

No certain, constant connection between senile cataract and any other disease has as yet been definitely established. There is an undoubted hereditary tendency, which appears to descend by the male rather than the female line, although the condition is no more frequent in the one sex than the other. Many individuals with senile cataract exhibit no other symptoms of senility; in others, atheromatous degenerations of the arteries are more or less evident. Diabetes sometimes coexists with senile cataract. In most cases there is probably no connection between the two conditions, although there undoubtedly exists

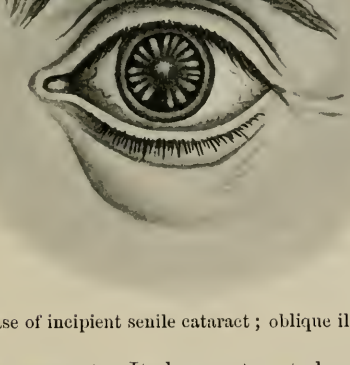


FIG. 76.—Case of incipient senile cataract; oblique illumination.

a true *diabetic cataract*. It has not yet been satisfactorily shown, however, how diabetes produces cataract. Only a very small number of diabetic cases are complicated by cataract, and repeated experiments make it appear pretty certain that the small amount of sugar contained in the nutrient liquids of the eye cannot be the direct cause. It is more probable, indeed, that the malnutrition and general cachexia give rise to the lenticular opacity in those predisposed to cataract, or in whom the conditions are otherwise favourable. Senile cataract is met with in a constantly increasing proportion of individuals living from the age of 50 upwards. After 80 years of age the relative frequency appears to be considerably less.

The *diagnosis* of cataract presents no difficulties when no

complications exist in the anterior portion of the eye, such as dense opacities of the cornea, occlusion of the pupil, etc.

By reflecting light into the eye with the ophthalmoscope, we at once see, in the form of black patches or striæ on the yellowish-red background, formed by the light which reaches the observer's eye from the fundus, any opacity or opacities which may exist in the lens, while when the cataract is complete there is an absence altogether of any reflex from the fundus of the eye.

If the lens be merely examined by oblique illumination, and not dioptrically with the ophthalmoscope, the senile greyish reflection is apt to suggest an opacity which does not in reality exist, and the transparency of the lens can be at once seen by observing the unbroken reflection of light from the back of the eye.

The only *treatment* by which sight can be restored without too great a risk of destruction of the eye is by extracting the opaque lens. This is, as a rule, preferably done by shelling it out of its capsule, which must first be ruptured.

In certain cases the lens may be removed in its capsule. Operators differ as to the cases in which it is advisable to do this. There can be little doubt, however, that where any evident weakness in the ligament of the lens exists, and, still more, where there is more or less marked subluxation, this is the best operation.

After-cataracts form in cases in which the lens capsule has been left in the eye, and these opacities may attain such a density as to render a subsequent operation necessary. The secondary intransparency generally forms after the lapse of some months, and is the result of a proliferation of the cells of the anterior capsule, as well as an entanglement of cortical substance, which has not been removed at the time of extraction, or absorbed during the healing process. Where there is any inflammatory exudation this becomes matted, too, with the opaque capsule, and adds to the density of the screen thus formed.

The operations required for after-cataract are performed with the view of removing the opaque screen from the line of sight without removing it from the eye. When the main opacity is not in the axis of vision no operation is required. Where severe and prolonged iritis has followed the operation for the extraction of a cataract, there is not only a denser after-cataract formed, but the pupil is drawn up to the wound in the external coats of the eye, with the result that the vision is destroyed. If under these circumstances, however, there still remains some

perception of light, it is possible, by performing the operation of iridotomy, to improve matters. The amount of vision which the patient recovers after such an operation depends greatly on the state of the vitreous. Often it is much clouded by exudation or the semi-organised remains of exudation, which after a time, if there is no fresh inflammation, may clear away to a very considerable extent. There is a great tendency to recurrence of inflammation, however, after iridotomy, which on this account should not be performed until the eye has come absolutely to rest. The opening should be made as large as possible, to prevent reclosing, should there be inflammatory reaction.

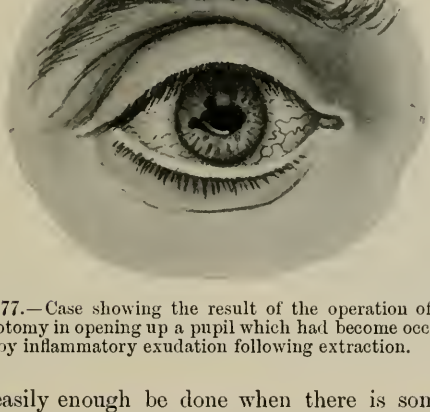


FIG. 77.—Case showing the result of the operation of iridotomy in opening up a pupil which had become occluded by inflammatory exudation following extraction.

This may easily enough be done when there is some retractile power in the iris, but in cases where the fibrinous deposit behind the iris is dense and tough, and the iris itself altered by inflammatory infiltration or atrophied, it is often extremely difficult. In such cases it may be necessary to cut out a triangular-shaped bit of the opaque screen.

The simpler after-cataract operations may be done after the lapse of a fortnight from the time of the extraction. But where there has been any marked inflammatory reaction after the first operation, the eye should have been absolutely free from irritation for several weeks before anything further is attempted.

With regard to extraction, both eyes should never be operated on at the same time. The reasons are obvious. The operation

is itself a more serious one when both are done. There is the possibility of some unforeseen accident happening, independent perhaps altogether of the nature of the operation, and avoidable on a future occasion; or some unfavourable condition, interfering with the success of the first operation, may necessitate a modification in the operation for extraction in the other eye.

Only a very few instances are recorded where a spontaneous cure of senile cataract has taken place, owing to absorption within the capsule. The process is a very slow one, yet one which is sometimes very complete. In one of the cases which have come under my own observation the spontaneously cured eye had better vision than the other one on which I had successfully operated eleven years previously. Probably the infrequency of spontaneous cure depends entirely upon the lapse of time required for it to take place. On this account it need not be taken into consideration in the treatment. No medical treatment is known which will promote this natural cure. Occasionally a cure is effected by an accidental dislocation of the opaque lens.

After an extraction of cataract, the eye does not immediately recover the full amount of sight of which it is capable, but goes on improving from day to day for a length of time, which varies considerably in different cases, usually, however, for at least a fortnight or three weeks. The cause of this improvement is to a great extent the absorption which takes place of the cortical matter left in the eye, and consequently it is slower, on the whole, the more incomplete has been the clearing away of the lens substance. In many cases, too, there are slight intransparencies in the cornea which only slowly clear away completely.

After the removal of the lens, the eye is of course left very much out of focus, and becomes highly hypermetropic. The condition of the eye when the lens is absent is called *aphakia*, and the degree of hypermetropia varies according to the build of the eye and the state of previous refraction. The higher the previous hypermetropia, the higher of course is the aphakic hypermetropia; whereas, on the other hand, there is less hypermetropia in an aphakic eye, the higher has been the previous degree of myopia. Sometimes the previous myopia has been exactly sufficient to neutralise the refractive change produced by the operation, so that emmetropia is the result, or there may even be some myopia left after the lens has been removed. Much most frequently, however, convex glasses are required before any sharp retinal images are formed; and as with the

absence of the lens there is an impossibility of any accommodation of the eye, absolutely clear images can, with the same glass, be received from objects at one distance alone. The practical result of this is, that at least two different strengths of glasses have to be worn, one for distant vision, and the other for reading. If the eye has been previously emmetropic, the glass which is required for distant vision is usually + 10·0 or + 11·0, while for reading + 14·0 or + 15·0 suffices.

Vision is often improved by the addition of a cylindrical lens to the spherical one, as some astigmatism is frequently acquired, owing to a flattening of the cornea in a direction at right angles to the incision. The amount of astigmatism varies in different cases. The presence and character of a previously existing regular astigmatism will necessarily have an influence in this respect. It is some time before complete consolidation of the cicatrix leads to a final shape of the cornea, so that it is not often advisable to prescribe the sphero-cylindrical spectacles until the astigmatism has acquired its permanent degree. There is some difference of opinion as to when spectacles may be worn. Much reading should certainly not be allowed until three or four weeks have elapsed since all redness has disappeared from the eye.

Fig. 78.—Case of lamellar cataract; oblique illumination.

Two forms of juvenile or *congenital* cataract are of common occurrence, namely, *lamellar cataract*, which is a partial cataract, *i.e.*, one in which the opacity only involves part of the lens, and *complete congenital* cataract.

Lamellar cataract is probably most frequently congenital, although it undoubtedly often makes its appearance in early childhood. In the great majority of cases it exists in both eyes, very rarely in one alone. The degree of visual disturbance which it causes varies very considerably according to the density of the intransparency and the amount of lens substance which it involves. In some cases the density of the opacity is so slight that hardly any defect of vision is produced. In other cases, again, a considerable degree of blindness results from a dense opacity. Between these two extremes all degrees of visual dis-

turbance are met with. The condition interferes to some extent, though probably never completely, with accommodation, and is often associated with myopia, the amount of which is usually slight.

When a lamellar cataract is examined by oblique illumination (see Fig. 78), the first appearance that strikes one is a tolerably uniform greyish opacity, which does not extend as far as the equator of the lens, and is more dense at its margins, from which often a few striæ pass towards the capsule. On closer examination the lamellar nature of the cataract can often be made out; that is to say, it is not difficult, as a rule, to satisfy one's-self that the opacity is limited to one or more contiguous lamellæ, within, as well as external to which, the lens is transparent. The cause of the greater darkness of the margin is the relatively greater opacity which is caused by the anterior and posterior portions of the intransparent fibres meeting here. In this way, too, lamellar cataract differs greatly from other forms of cataract, which are usually darkest at the centre, where the opacity is deepest. It is seldom that the opaque layers, instead of being contiguous, enclose transparent lamellæ.

Fig. 79.—Lamellar cataract; ophthalmoscopic illumination.

The opacity occupies very different lamellæ in different cases, and consequently the diameter of the opaque area differs; there is never, however, an opacity of the layers immediately under the capsule. In some cases short striæ are to be seen, both in the anterior and posterior cortex. The cause of the intransparency appears to be some arrest of development, at a time during intra-uterine life or early infancy, when the intransparent layers were the most superficial. There is little doubt that it is a rachitic change, and is sometimes associated with absence or defect of enamel on some of the teeth.

Lamellar cataract usually, though by no means invariably, remains stationary. This variety of cataract is often overlooked until the patient attends school, and attention is drawn to it by

the accompanying amblyopia or myopia. The amount of amblyopia is very variable in different cases.

The *operations* performed for lamellar cataract are iridectomy, removal of the lens by discission, and extraction. Where there seems a likelihood of improving vision by displacing the pupil, which can be inferred when the vision, with proper optical correction if necessary, is improved by dilatation of the pupil, there may possibly be some justification for performing iridectomy, even when the amblyopia is comparatively slight. Removal of the lens, on the other hand, is attended not only with some risk —certainly very slight—but also introduces more inconvenience by rendering all accommodation impossible, and should not be undertaken unless vision is less than one-third of the normal. The choice of operation is in some measure influenced by the conditions as to probable progression of the opacity. Where there is good reason to believe that a recent deterioration in vision has taken place, which is not due to increasing myopia, discission may be performed even although the visual acuity is greater than one-third of the normal. In most cases for which iridectomy is performed, it should be done upwards, as it might be necessary at some later period to extract the lens. In this situation, besides, it is less unsightly, and less liable to cause any disagreeable dazzling. Personally I have practically given up iridectomy for lamellar cataract.

Congenital total cataract is usually soft, and involves all the layers of the lens. It is frequently also complicated by a capsular opacity as well. These cataracts, too, undergo further changes in the course of time, and become shrivelled up and membranous, or in part calcareous. Degenerative changes, which take place in the suspensory ligament, often lead to their eventual dislocation. There is a variety of congenital cataract in which the opacity is mainly cortical, while a sclerosed nucleus occupies the centre of the lens. The best *treatment* for this form is to extract, just as in senile cataract. The more common form only requires discission, though, when calcareous patches exist, this has often to be followed very soon by evacuation of the swollen lens substance, as well as of the calcareous patches, through a small linear incision in the periphery of the cornea, owing to the irritation which the calcareous matter often produces when it lies in the anterior chamber. In the shrunken membranous cases, with opacity of the capsule as well, the most satisfactory result is obtained by dragging the whole capsule out of the eye. This is apt to cause irritation unless done carefully. The membrane should be seized with a pair of capsule forceps,

and very gently and slowly, and, as it were, coaxingly, drawn out. If the resistance be very great, as much as will come without too great traction may be cut off with the iris scissors, and the rest left. Sometimes, instead of extracting, it is possible to get a good hole in the membrane with one or two cataract needles, or by cutting it across with a pair of de Wecker's scissors. The toughness of the structures generally, however, renders such efforts not very successful.

Secondary cataract most frequently begins with an opacity of the posterior portion of the lens,—what is called *posterior polar cataract*,—and is often very slow in advancing to other parts of the lens. The opacity is the result of malnutrition, and is most commonly met with where there is disease of the vitreous, retina, or choroid. An opacity beginning at the posterior pole should always raise a suspicion of being secondary, and it will generally be found that the vision does not correspond to the opacity, and

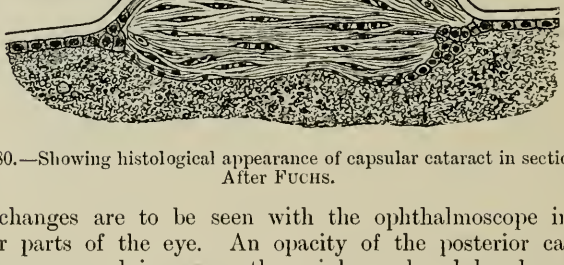


Fig. 80.—Showing histological appearance of capsular cataract in section.—After Fuchs.

that changes are to be seen with the ophthalmoscope in the deeper parts of the eye. An opacity of the posterior capsule rarely occurs, and is apparently mainly produced by deposition on it from the vitreous.

Stationary partial cataracts, in which the opacities are sharply defined and punctiform or irregularly linear in shape, and in different parts of the lens, are occasionally met with. They rarely produce any great defect of vision.

Capsular cataract may exist without any accompanying opacity of the lens. It is most commonly in the form of what is called *pyramidal cataract*,—a conical protrusion of a central portion of the anterior capsule, which is at the same time densely opaque.

Sometimes pyramidal cataract is congenital, and then almost invariably bilateral. The pathology of this variety is not clear, but it seems to be the result of a retardation in the closure of

the capsule. As a rule, however, the capsular opacity is set up when the lens is for some time pressed up against the back of the cornea, after a perforation due to ulceration. Under these conditions, a proliferation and fatty and fibrinous degeneration takes place in the cells lining the capsule, and the homogeneous capsule itself is portruded in front of this. In consequence of this origin, there is almost always to be seen some scar in the cornea, indicating the position of the perforation. In many cases this is extremely faint, as the perforation has usually taken place in infancy, as the result of ophthalmia neonatorum, and the cicatricial tissue has gradually assumed an almost complete transparency. Often there is nystagmus in eyes with pyramidal cataract, and the vision is found to be more defective than can be accounted for by the limited opacity. The combination of pyramidal cataract with nystagmus is indeed almost a certain evidence of pre-existing ophthalmia neonatorum, or very early and extensive ulceration of the cornea.

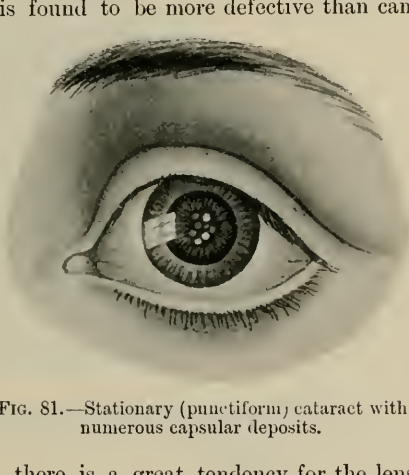


Fig. 81.—Stationary (punctiform) cataract with numerous capsular deposits.

Traumatic cataract.—The transparency of the lens depends, under normal conditions of nutrition, on the integrity of the capsule. As soon as there is a breach in its continuity, there is a great tendency for the lens fibres to become opaque. The most common cause, then, of traumatic cataract is a wound of the lens capsule. A severe blow on the eye, without any penetrating wound, is—less commonly, however—followed by cataract, which must consequently be considered traumatic. In such cases it is doubtful whether the capsule is ruptured or not. Probably in all cases where a rapid opacity takes place it is; indeed in some the rupture can be seen. In others, again, in which cataract slowly forms, the accompanying changes in the eye produced by the injury must be supposed to have in some way caused an interference with the nutrition of the lens.

It is extremely rare that the capsule is injured without being perforated, as it is not often that the body which has perforated

the external coat of the eye penetrates just sufficiently to scratch the capsule and no more.

If the hole made in the capsule is very small, it may sometimes heal without any opacity of the lens resulting. But even small ruptures, by admitting the aqueous humour into contact with the lens fibres, are apt to lead to cataract; an extensive rupture invariably does so, and some of the lens substance usually escapes into the anterior chamber, where it swells up, breaks down, and becomes absorbed.

The results obtained by treatment in the case of traumatic cataract are, on the whole, very much less favourable than for

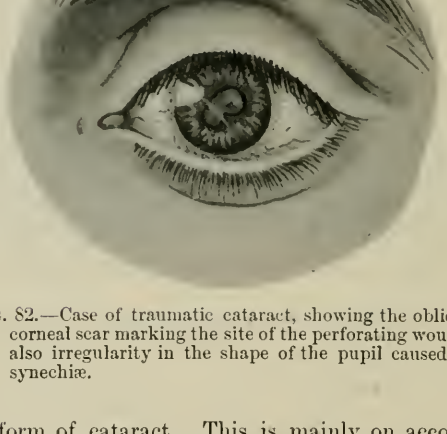


Fig. 82.—Case of traumatic cataract, showing the oblique corneal scar marking the site of the perforating wound, also irregularity in the shape of the pupil caused by synechiæ.

any other form of cataract. This is mainly on account of the liability that there is for other parts of the eye to be involved in the injury, or to become subsequently inflamed. Much depends, too, upon whether or not septic matter is introduced into the eye by the body with which it is wounded. The worst cases are those, of course, in which a foreign body is lodged in the eye. When the wound in the capsule is large, and a considerable proportion of the lens matter falls into the anterior chamber, a good deal of irritation is often set up, even when there is no septic element present. This is more likely to happen in adults, in whom the lens is harder and more irritating than in young individuals.

The *treatment* in all cases where the cataract has been caused by a perforating wound, should consist in bathing the eye frequently with a weak solution of corrosive sublimate, and in keeping the pupil well dilated, if possible, with atropine. Where there is much irritation, a careful examination should be made, in order, if possible, to determine the cause of it. If the rupture has been small, the lens is often found to be swollen in its capsule; and, when this is the case, a larger opening should be made with a cataract needle, followed in a couple of days by removal through a linear incision of as much of the opaque lens as can be got away without any great difficulty. A more complete evacuation may be got by combining this with irrigation with warm neutral salt solution. Even if this should not

FIG. 83.—Case of traumatic cataract in which the swollen lens matter lies far forward in the anterior chamber.

dislodge the remaining lens matter, it is a useful precaution in case any infection should have been introduced at the time of the accident. If the irritation is due to lens matter lying in the anterior chamber, a linear extraction may be performed at once. When it is evident that septic matter has been introduced, it is a good plan to combine the extraction with a good-sized iridectomy, and to freely irrigate the anterior chamber with very weak chlorine water, afterwards using antiseptic dressings. An eye may sometimes be saved in this way, though at the risk of more or less permanent opacity of the cornea, owing to destruction of the epithelium lining its posterior surface. In some cases, however, in which the external wound is small and the reaction great and evidently due to infection, the following

treatment may be tried—The wound is cauterised freely with the thermo-cautery; freshly prepared, fully saturated chlorine water is then injected subconjunctivally, and some time allowed for the inflammatory symptoms to subside before proceeding to the removal of the cataract. When complicated with prolapse of iris, the prolapsed portion should generally be excised, and as much as possible of the opaque lens matter removed through the corneal wound. In cases where the irritation is slight, and tends to subside under simple treatment, it is, as a rule, better to leave the cataract alone until the eye has come completely to rest. Absorption often goes on without any interference, or it may be hastened, when slow, by stirring up the lens once or twice with a cataract needle.

A traumatic cataract, instead of becoming absorbed, may undergo different changes, which are for the most part similar to those already described as occurring in other over-ripe cataracts.

Very rarely there is the formation of true bone in the lens. In such cases it is always present in the choroid as well. Ossification never takes place unless the capsule has been ruptured, therefore only in traumatic cases.

Besides by absorption, there is another way in which traumatic cataract may undergo a spontaneous cure. A gradual clearing up of the opacity may take place. This is only met with, and that very rarely, when the capsular wound has been small and rapidly closed, while the opacity in the lens itself has been limited to the track of the body with which the eye has been wounded.

Traumatic cataract may be produced by wounds from almost every object which could possibly be imagined to be capable of penetrating the eye. An extremely common manner by which the lens is wounded is with a fork, which is often used by children to unfasten their shoe-laces. This accident is most frequently a severe one, as, apart from the double wound produced by the two prongs, septic matter is generally carried into the eye.

It is a common enough thing for the patients themselves, or those who come with them, to deny any accident. When the presence of a cicatrix in the cornea renders it certain that there must have been one, and this is explained to them, they will then often admit it. A unilateral cataract in a young individual is, in fact, almost invariably traumatic, although some difficulty is experienced sometimes in finding any trace of the situation in which the eye has been penetrated.

Glass-blowers' cataract.—Glass-blowers are subject to cataract, which more frequently seems to affect the left eye, or, at all events, to begin in the left eye. I have seen several cases of this form of cataract. There can be no doubt that the occupation in some way favours the occurrence of opacity of the lens. Probably it is the action of powerful actinic rays. The curious preponderance of the cataract in the left eye is due evidently to the position in which the head is held in blowing. This position not only brings the left eye nearer the glowing glass, but brings the right eye under the protection of the nose.

Cataract operations.—*Discission* or *needling* for cataract is practised in the case of lenticular opacities in young individuals. The object of the operation is to allow the aqueous humour to come in contact with the lens substance, which is thus macerated and slowly absorbed. To effect this, it is necessary to make an opening in the lens capsule, and at the same time break down, to some extent, the substance of the lens as well. The instrument used for this purpose is a sharp needle, the body of which is made almost imperceptibly tapering, and at the same time accurately rounded, so as to prevent any escape of aqueous whilst it is in use. Before operating, the pupil should be well dilated with atropine. Having taken a good hold of the conjunctiva close up to the cornea, with the fixation forceps held in the left hand, the needle, which has been rendered thoroughly aseptic, is pushed through a peripheral portion of the cornea until it reaches the capsule of the lens. The handle is then slightly depressed, and at the same time the needle pushed a little farther through the cornea, and then, by a movement round the portion of it which is grasped by the cornea as axis, it is made to make a cut through the capsule in a vertical or nearly vertical direction. It is then slightly withdrawn, and a horizontal incision made through the capsule in the same way. The capsule is thus opened by a crucial incision, and after this has been done, more or less of the lens may be stirred up with the end of the needle, care being taken that the whole thickness is not pierced at any place. The needle is then withdrawn, the eye washed with a stream of warm sterilised water, and a bandage applied. For some time afterwards the pupil must be

Fig. 84.—Cataract stop-needle.

kept well dilated with atropine, so as to prevent any synechiæ forming.

The main point in the operation consists in making a satisfactory opening in the capsule. If the needle be merely stuck into the lens, and the point then moved about so as to stir it up, a proper absorption does not follow, and there is a risk besides of rapid swelling taking place within the capsule, which may give rise to considerable irritation.

In children no further operation is absolutely necessary, as a rule. Every case should, however, be carefully watched for some days afterwards, as it occasionally happens that when a considerable quantity of macerated and swollen opaque lens matter falls all at once into the anterior chamber, it interferes with the normal excretion of the liquids of the eye, and may thus give rise to glaucomatous symptoms. When this occurs, there is often at the same time pain and vomiting. It is the more likely to occur the older the individual on whom the operation is performed, and the more freely the lens has been needled. Under these circumstances it is necessary to extract as much of the lens matter as can be readily got away from the anterior chamber. There are different ways of doing this, but the best is by making a small *linear extraction*. This is done with a keratome (see Fig. 157). The keratome is entered through the apparent corneo-scleral margin, taking care that the wound is perpendicular to the surface. The incision thus made should be 4 or 5 millimetres in length. After withdrawing the keratome, the upper lip of the wound is depressed with a small scoop, along which the aqueous and lens matter are allowed to escape. If the whole of the contents of the anterior chamber do not come at once in this way, the eye may be closed for a minute or two, and the manœuvre repeated. It is best, if possible, to avoid introducing the scoop frequently into the chamber, and in any case it is not necessary, although of course it hastens matters, to extract all the lens substance.

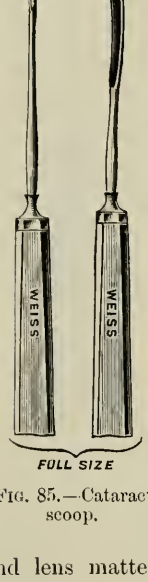


Fig. 85.—Cataract scoop.

Many surgeons make a practice of always extracting a few days after needling, whether that be followed by any irritation or not. The time required for the cure of the cataract is thus

shortened, and, if a linear extraction performed in the way described be practised, with proper aseptic precautions, it is a very safe proceeding. There is necessarily, however, a slight increase in the risk as compared with needling alone and leaving the absorption to take place in the course of nature.

The broken-up lens matter may also be removed by the method of *suction*. Having made a linear incision in the cornea in the manner already described, the nozzle of a suction syringe is introduced well into the anterior chamber, and the softened lens matter slowly sucked up into it. Two forms of syringe are used, Bowman's and Teale's. In the one the suction is got by means of raising a piston with the thumb, while the tube of the syringe is firmly held by the first and second finger inserted into two rings fixed to the tube. The other suction curette consists of a silver nozzle attached to a glass tube 4 or 5 in. long, ending in a flexible indiarubber tube, with a glass mouthpiece at the other end. The suction is made with the mouth. Those who attempt removing lens matter by suction should pay attention — first, to securing the absolute asepticity of the syringe; and, secondly, to the manner in which they hold it in the chamber. An instrument of this kind, it must be remembered, is more difficult to render aseptic than most others. The nozzle has its opening on its anterior surface, consequently it is necessary,

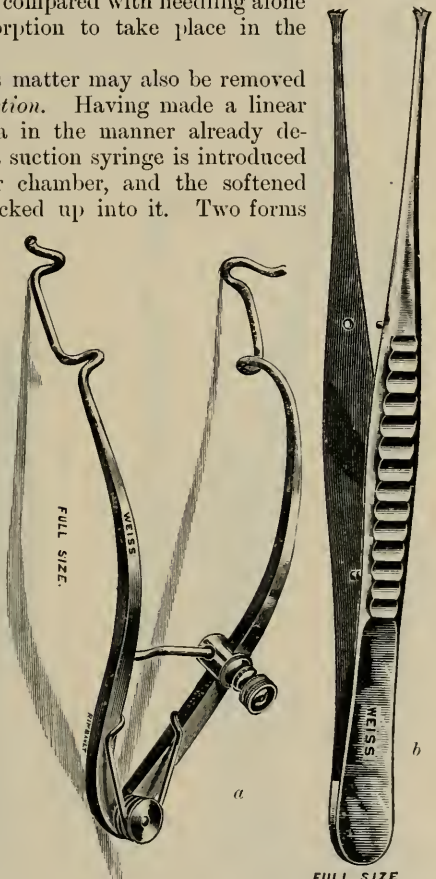


FIG. 86.—*a*, Spring speculum; *b*, fixation forceps.

in order to avoid having to exert too powerful a suction, to get it well behind the matter which it is desired to suck up. Care must also be taken that it does not get behind the iris, or be allowed to enter so deeply that the posterior lens capsule is ruptured. Very pretty results may be obtained by this method; but it is very questionable whether on the whole it is better than the simple linear extraction, and it is certainly not so safe.

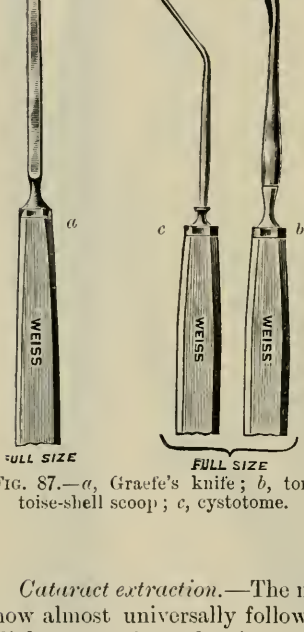


FIG. 87.—*a*, Graefe's knife; *b*, tortoise-shell scoop; *c*, cystotome.

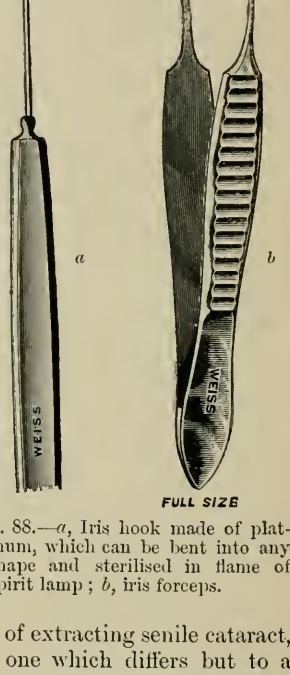


FIG. 88.—*a*, Iris hook made of platinum, which can be bent into any shape and sterilised in flame of spirit lamp; *b*, iris forceps.

Cataract extraction.—The method of extracting senile cataract, now almost universally followed, is one which differs but to a slight extent from that introduced by von Graefe as his modified linear operation.

The instruments required for extraction with iridectomy are the following (see Figs. 86 to 89):—A spring speculum, a fixation forceps, a narrow cataract knife (Graefe's knife), a pair of iris forceps or iris hook, iris scissors, a cystotome or capsule forceps, and a tortoise-shell scoop, generally fixed at the other

end of the cystotome, as in Fig. 87. Further, in case they should be required, there should be at hand a caoutchouc or tortoise-shell spud for replacing the iris, and a wire vectis to remove the lens, should it become dislocated, or should there be any early escape of vitreous. It is useful to have also a wire elevator (Fig. 90), which can be used when the speculum has been

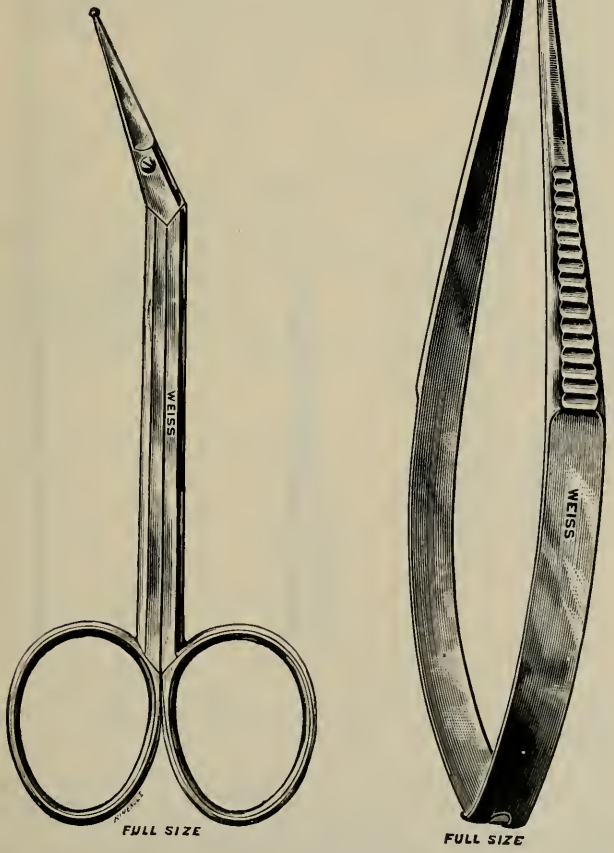


Fig. 89.—Iris scissors.

removed, if it should be necessary, or appear advisable to remove that instrument before the completion of the operation.

After the eye has been cocainised, and the conjunctival sac well washed out with corrosive sublimate solution, 1 to 5000, the speculum is introduced. The form of speculum shown in Fig. 86 is a useful one, as it can be used for either eye without getting in the way, and is sufficiently strong, owing to the rectangular shape of the arms, to resist any attempt on the part of the patient to close the eye. If the operator uses his right hand for making the section, he will stand behind the patient when operating on the right eye, and in front of him when

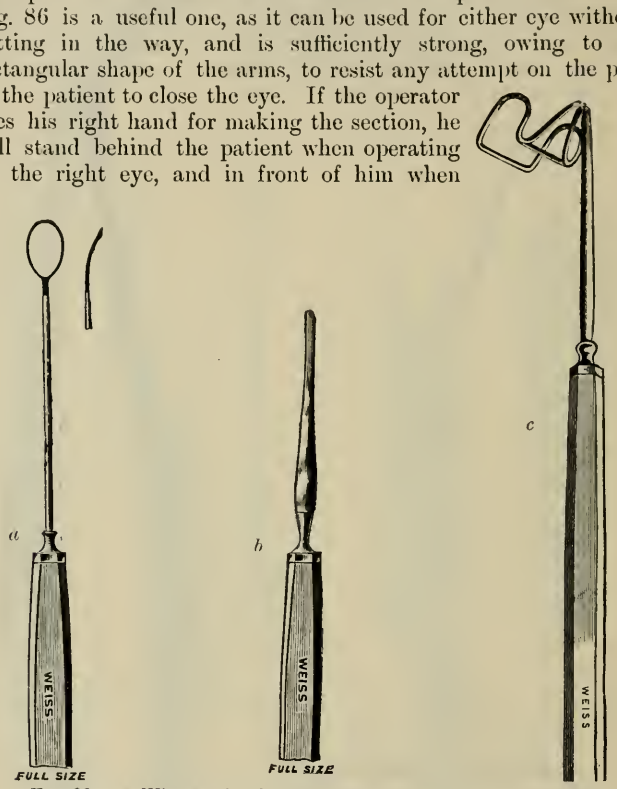


FIG. 90.—*a*, Wire vectis; *b*, tortoise-shell spud; *c*, wire elevator.

operating on the left. This is necessary, as, owing to the nose getting in the way, the section has to be made from the temporal side.

A firm hold is taken of the conjunctiva and subconjunctival tissue, close up to the cornea, with the forceps held in the left hand. This fixation should generally be made in a line with the vertical diameter through the cornea, and therefore exactly

opposite the mid-point of the section about to be made. If fixation be made at any other place, it may interfere with the proper performance of the section. The knife is then entered by making a *puncture* at the corneo-scleral margin, and at a point on a level with a semi-dilated pupil. In making the puncture, the point of the knife is directed towards the centre of the pupil, or rather lower. As soon as it has properly entered the chamber, it is steadily pushed forwards, while being gradually given a direction parallel, or nearly so, with the horizontal diameter through the cornea, until its point catches in the angle of the

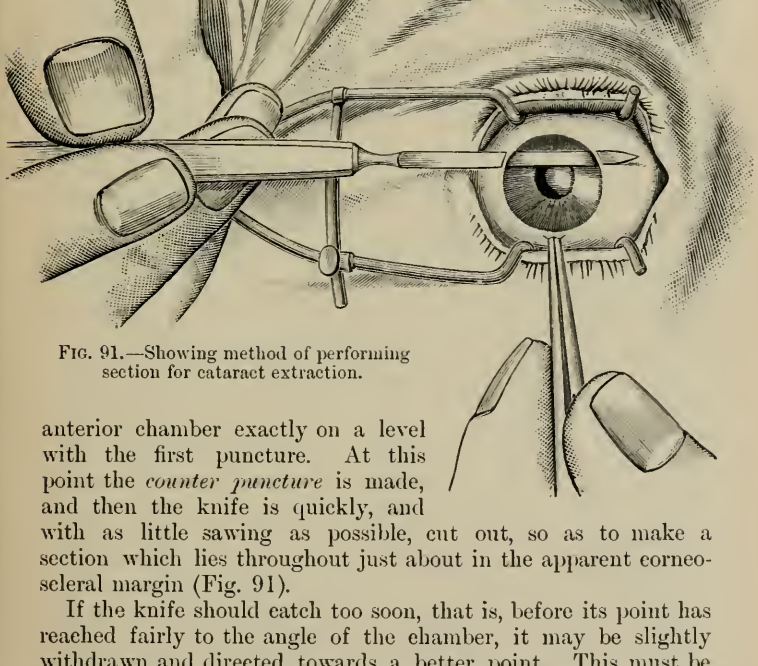


FIG. 91.—Showing method of performing section for cataract extraction.

anterior chamber exactly on a level with the first puncture. At this point the *counter puncture* is made, and then the knife is quickly, and with as little sawing as possible, cut out, so as to make a section which lies throughout just about in the apparent corneo-scleral margin (Fig. 91).

If the knife should catch too soon, that is, before its point has reached fairly to the angle of the chamber, it may be slightly withdrawn and directed towards a better point. This must be done carefully, and without increasing the size of the opening at the puncture, so as to retain the aqueous humour as far as possible. Sometimes, owing to the aqueous escaping, the iris falls in front of the knife immediately after the counter puncture has been made. When this happens, two courses are open to the

operator,—either to withdraw the knife slowly, and postpone the operation for some days, or proceed with the section, cutting through the iris at the same time. The latter does not interfere altogether with the successful termination of the operation, although it may complicate it by causing bleeding into the anterior chamber.

After the section has been made, if there be any little flap of conjunctiva, it should be turned over on to the cornea, so as to free the lips of the wound. A piece of iris is then removed with the iris forceps or iris hook and scissors. Personally, I always use the hook, which, being made of platinum, can be sterilised by holding it in the flame of a spirit lamp, and which can be readily bent into any shape best suited for easy introduction. The use of the hook has the advantage, too, of causing no pain, as with it the margin of the pupil, not the surface of the iris, is seized. A small iridectomy, 4 to 5 millimetres in width, is all that is required; it is therefore not necessary to exert any great traction with the forceps or hook, care being taken only that the pupillary margin is drawn out. The cutting should therefore also be made with one snip, and not, as was at one time very much practised, by means of several snips, freeing first the one side, and dragging out as much iris as could be got. By cutting the iris in this manner, and by making the incision in the way described, and not more peripherally, as was formerly done, we may to a great extent avoid any encleisis of the iris. After the iridectomy has been completed, it is well to see that the iris is free. If not, a little friction made with the lid over the eye will generally be sufficient to free it; but, should this not be the case, recourse may be had to the caoutchouc spud, which can be used to much greater effect at this stage of the operation than after the lens has been removed. If there is now any manifest pressure of the speculum on the eye, or if the patient is unruly, that instrument should be removed, or an assistant may be allowed to hold it in such a way as to avoid any pressure. The cystotome is then introduced into the anterior chamber, the cutting edge or pricking point being held parallel with the surface of the lens, until it has been pushed as far down as the lower margin of the pupil, or, if it can be done without any difficulty, even behind the iris in this situation. The point is then directed to the lens, the capsule of which it readily pierces, and in which it is made to tear an opening by being steadily withdrawn in a vertical direction towards the external incision. A similar rent is then made in the capsule at right angles to this one, and as nearly as may be along its upper circumference. In

this way an irregular T-shaped opening in the capsule is obtained.

The object of opening the capsule is to permit of the easy escape of the lens. It is a point which has always been much discussed, which is the best way of doing this? I am not prepared to say that the way just described is better than any other that may be employed; but what is pretty certain is, that the more free the opening can be made the more easily and completely can the opaque lens be removed. Care should therefore be taken that the cystotome really cuts the capsule, and is not allowed to pass in between it and the lens after having made a rent in it. It is to avoid the possibility of this that it is well to pass it far down first, and then to cut towards the periphery. A good opening can be got by using a pair of capsule forceps instead of a cystotome. The forceps are passed in closed, until the points are slightly beyond the centre of the lens, when they are opened, pressed gently against the surface of the capsule, and closed. They are then withdrawn slowly and by a slight side-to-side movement. In order to see whether they have removed a satisfactory portion of the capsule, they may be transferred at once to the dish containing the antiseptic lotion, and the portion of capsule allowed to float off. The capsule forceps are somewhat more difficult to manipulate than the cystotome. Care must be taken not to press too firmly on the lens, as it may readily in this way be dislocated. They must also be held in such a way as to avoid their catching, farther back from the points, in any of the tissues in the external incision, which would much interfere with its tearing away a portion of the capsule. Where a cataract is complicated with an opacity in the capsule, the forceps are far more satisfactory than the cystotome, as by using them the opacity is removed at the same time that the capsule is properly opened. This proceeding is generally safer than removing the capsular cataract after the lens has been extracted.

The next step in the operation is to effect the removal of the lens. For this purpose external pressure has to be made. The back of the tortoise-shell scoop is applied to the lower part of the cornea, and pretty firm pressure exerted. This causes the wound to gape, and the upper circumference of the lens to become engaged in it (see Fig. 92). When the lens has properly presented in this way, the pressure is increased, and at the same time the scoop gradually caused to follow it upwards as it becomes more and more disengaged, until it is finally completely expelled. After this has been accomplished, it is well to wash out the con-

junctival sac again with the antiseptic lotion, and then, by pressing and rubbing up the lower lid against the cornea with the thumb, any cortical matter which has been rubbed off and remains in the eye is to be, as far as possible, got rid of. During this coaxing out of the cortical matter, care should be taken to keep the eye well washed with the corrosive sublimate lotion, as it is otherwise not free from danger, owing to the possibility of micro-organisms being carried into the wound from the lid. It is better, however, except where there is dacryocystitis or chronic conjunctivitis, to make the necessary pressure on the cornea through the lid, and not directly, as it can be done with less irritation or injury to the cornea.

An idea of the completeness of the removal of the cortex

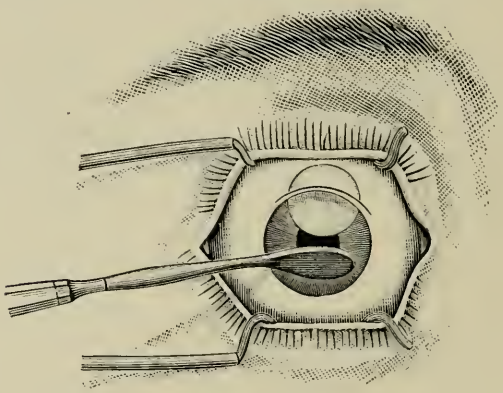


Fig. 92.—Lens escaping through incision.

may be got before applying the dressing, by seeing whether the patient can count fingers or not. If this can readily be done, it shows that the pupil is clear. If the operation has been performed for an unripe cataract, there may be some clear cortex remaining, but all opaque matter at all events has been removed from the line of vision. When this clearing has been made to a sufficient extent, or as far as may be advisable in any particular case, the caoutchouc spud should be run along the wound, in case any piece of capsule or cortex should be caught in it. If there should be any clotted blood, too, it must be removed with the iris forceps, and attention must be paid to the pupil, and any catching at the angles of the wound rectified in the manner already described. A dressing must be then applied.

Different dressings are used by different surgeons. The following may be recommended :—Next the eye, which is gently closed, is placed a piece of lint soaked in the corrosive sublimate solution. A pad of absorbent cotton-wool is then put on the top of this deep dressing, and kept in position by a couple of strips of adhesive plaster. Over this is placed a light shield of aluminium, by which the eye is protected from any slight knock which the patient might inadvertently give it. This dressing is not changed for twenty-four hours, and after the eye has been examined, and if necessary bathed with a little warm sterilised water, is reapplied as before. The same dressing is continued, and changed every twenty-four hours, for four or five days, after which all that is required is a pair of dark glasses during the day, and the aluminium shield at night. If, as is generally the case, the chamber has re-formed within the first twenty-four

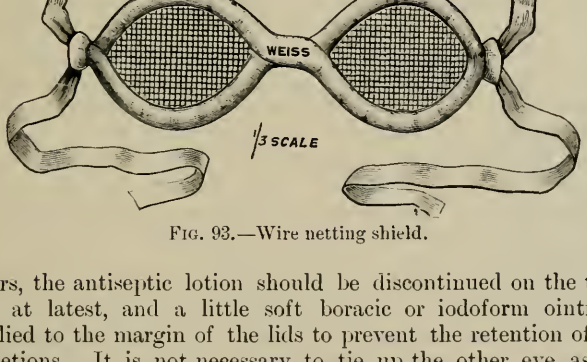


Fig. 93.—Wire netting shield.

hours, the antiseptic lotion should be discontinued on the third day at latest, and a little soft boracic or iodoform ointment applied to the margin of the lids to prevent the retention of the secretions. It is not necessary to tie up the other eye, as the patient himself does not move either eye much, owing to the pain which this causes, until the anterior chamber has re-formed. The wound has generally so far healed by the time the first dressing is changed, as to have permitted the chamber to become re-established. If there should be no chamber after two days,—an unusual though occasional occurrence,—it is better to remove the dressing altogether and use the shield alone, or a double wire-netting shield, as shown in Fig. 93. The patient should be kept in bed for a couple of days at anyrate, unless he should be very corpulent, or should suffer from diabetes, when it is generally inadvisable to keep him in bed after the

first day. For the first few days it is as well to keep the patient in semi-darkness, where this is possible; he should at anyrate be protected from any strong light falling directly on the eyes.

If during the attempt to force the lens through the external wound any of the vitreous should escape, it becomes necessary to abandon the pressure on the cornea, as this would only cause further loss of vitreous without resulting in the escape of the lens. The lens has then to be extracted with the vectis (see Fig. 90). This instrument is pushed well behind it, by first being passed backwards, taking care not to dislocate it any farther. When it has been got well in position behind the lens, it is withdrawn slowly, a slight pressure forwards being exerted all the time, so as to prevent the lens from slipping off by supporting it against the cornea in front. It is generally necessary to leave most of the cortical matter which may not have been extracted with the vectis. Some of it may be removed by carefully introducing the curette, but this proceeding should not be repeated too often; and if there has been a good deal of vitreous expelled at the same time as the lens, should not be tried at all. When there has been an escape of vitreous, extra care must be taken when examining the eye afterwards.

Syringing out of the anterior chamber has been recommended in cases where it is difficult to remove cortical matter, as where the cataract has been immature at the time of operation. This is used instead of the external pressure exerted either directly on the cornea or through the lid, as has just been described. It is seldom, however, that when the capsule has been properly opened, and some time given for a little aqueous humour to accumulate, any such proceeding is called for.

When an extraction has been performed in an eye where there has been any dacryocystitis or conjunctivitis, it is a good plan to cover up the wound with a thick layer of finely powdered iodoform. Such eyes are better left without a bandage, although it is safer to use the protecting shield.

In a very considerable proportion of cases of extraction some degree of iritis takes place during the healing process. As a rule this is very slight, but wherever there is any indication of it, atropine should be used to prevent much adhesion to the lens capsule.

The most unfortunate accident which may happen after an extraction is suppuration of the corneal wound. If this goes on, it leads to more or less complete destruction of the cornea by extension of the inflammatory changes, and this, as well as a complication with purulent iritis, to which there is a tendency,

results in the loss of all useful vision, and not infrequently in the complete disorganisation of the eye. This accident is probably always due to septic inoculation of the wound. It generally begins, so far as it can be observed, after the first twenty-four hours. The chamber is then found to be empty, the conjunctiva reddened and chemotic, the edges of the wound are slightly infiltrated, and a greyish haze extends more or less distinctly down into the cornea. The patient complains of pain, and has often suffered during the night from sickness. When this state of matters is observed, no time should be lost in attempting to check the progress of the infiltration. This may be done either by using the thermo-cautery, or by applying a solution of nitrate of silver, 10 grs. to the ounce, directly to the wound. The eye should afterwards be frequently bathed with the corrosive sublimate solution, or, better still, with freshly prepared chlorine water.

In some cases of cataract it is advisable, instead of rupturing the capsule of the lens, to extract it as well along with the lens. Some operators even make this a rule. The result, as far as vision goes, is more immediately brilliant than when the capsule is left in the eye, but the operation is certainly much more risky, as it entails the loss of more or less vitreous, besides the irritation which may result from the tearing away of the suspensory ligament from its attachments. In all cases, however, where the lens is more or less dislocated, or where it is over-ripe and shrunken, and also where it has undergone calcareous degeneration, it should be extracted in its capsule. Pagenstecher's curette or spoon (Fig. 94) should be used for this purpose. It is introduced well behind the lens, which by it is pushed up against the back of the cornea; a tortoise-shell scoop is then used, with which pressure is exerted on the cornea, so as to cause the lens to glide slightly upwards on the large spoon. When it is found to move, the spoon is slowly withdrawn, whilst at the same time external pressure is kept up with the scoop, which is made to follow the other instrument as it is removed. This operation requires the aid of a skilled assistant to manipulate the external scoop, while the operator holds the fixation forceps in one hand and Pagenstecher's spoon in the

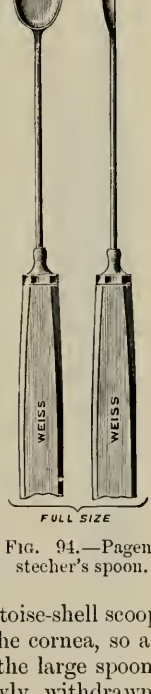


Fig. 94.—Pagenstecher's spoon.

other. When carefully performed, there need not be any great loss of vitreous; but that will depend to some extent on the consistency of the vitreous.

In cases of capsular cataract, and of shrivelled-up congenital cataract in children, the whole thickened opaque membrane may be removed with the capsule forceps through a fair-sized linear incision in the manner and with the precautions already described.

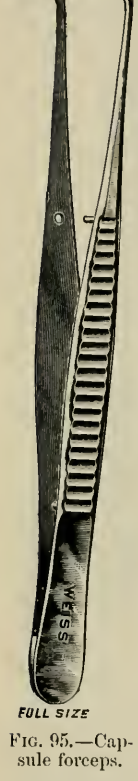


Fig. 95.—Capsule forceps.

If, owing to having made too small an incision, or to any other cause, considerable difficulty has been experienced in extracting a cataract, so that the scoop has had to be used more freely on the cornea than usual, there will be found on examining the eye next day a milky striated opacity of the cornea. This appearance, though it may last for a varying length of time, eventually clears off. It is due to injury to the cells lining the back of the cornea, and is favoured by the action of corrosive sublimate when some of the lotion used during the operation passes into the chamber. In some cases the appearance seems to be produced by folds in Descemet's membrane. In such cases it rapidly disappears.

An opacity due to cocaine has been described, but this I have never seen, though I have all along used it freely, and in combination with corrosive sublimate and different other antiseptics, as well as with mydriatics and miotics. There can be little doubt that this is due to the presence, in some specimens of cocaine, of an irritant alkaloid which cannot readily be separated from the cocaine. The opacity produced appears to be confined to the epithelial layer of the cornea, though it may nevertheless remain permanent.

Cataract extraction without iridectomy.—This is the so-called *simple* extraction, as opposed to *combined* extraction. Many surgeons appear to have almost completely abandoned the combined operation in favour of simple extraction. Others select the cases for which, in their opinion, the one operation is more suitable than the other. Which method is the one preponderatingly resorted to differs, of course, according to the circumstances which are allowed to influence the selection.

The main claims which have been made in favour of simple

extraction are that the cosmetic effect is superior, and that mutilation of the iris is avoided. The introduction of cocaine anæsthesia, and the rigid adoption of aseptic precautions, have made it possible to give effect to such considerations, which at one time would rightly have carried no weight. The great bugbear of simple extraction, on the other hand, is the possibility of subsequent iris prolapse. As regards the visual acuity which may be got by each method, probably few who have a large experience of both can confidently assert that there is any material difference. This, at all events, has been my experience.

It is not difficult to understand that those who were in the habit of making very large iridectomies, such as were the rule for some time after the introduction of the modified linear extraction, should have resorted to the simple operation and discarded iridectomy altogether. These large iridectomies are certainly unsightly, and the proportion of cases in which encleisis takes place, when the section is made as peripheral as von Graefe recommended, is by no means trifling. Besides, the large peripheral portion of the cornea, through which rays are thus permitted to reach the retina, is apt to render the image less sharp. On the other hand, the same disadvantages do not attend the performance of a small iridectomy and a less peripheral incision. There is little tendency to bad encleisis and little interference with vision, especially when the iridectomy is done upwards. The removal of the cataract is also easier if unripe, and the risks on subsequent bursting of the wound are less. Are, then, the only disadvantages a fresh wound in the iris and a less beautiful pupil? Those who have been in the habit of operating in this manner may fairly claim that the former disadvantage, which may even be got rid of altogether by the performance of a preliminary iridectomy, is at least outweighed by the diminished risk of encleisis or bad prolapse of iris in case of the wound bursting where no iridectomy has been done. The cosmetic advantages of a round active pupil, too, when it can be obtained, are altogether trifling in those elderly individuals who are the usual subjects of cataract extraction. It has to be borne in mind that whereas the combined operation is suitable for all cases of cataract, this is not so with the simple operation. Even those who make it a rule not to "mutilate" the iris, are in a certain proportion of cases obliged to do so.

There are, however, other and more important advantages in a simple extraction than the mere retention of a round pupil, if

the operation is performed by the method to be presently described.

On the other hand, there are unquestionably greater difficulties in the simple operation itself. There are, in addition, cases in which it is more or less unsuitable. A proper course, therefore,—that is, one calculated to give the best results in a large number of cases,—necessitates making a selection. If it were necessary to choose between the two operations one which should be put in practice in every case, I should unhesitatingly choose the operation with iridectomy. That operation, too, I should recommend to all whose experience of extracting for cataract is limited. Hence in talking of making a selection, I mean selecting the cases in which one may attempt to get the greater advantages of the simple operation with the best chances of success.

The best method of performing simple extraction is one which, so far as I know, is due to Professor Snellen of Utrecht. The incision is large, occupying half the circumference of the cornea. It lies in the apparent corneo-scleral margin, and is made with a large and broad conjunctival flap, the knife being carried for fully a quarter of an inch below the conjunctiva before cutting out, after the section at the corneo-scleral margin is completed. The cystotome is introduced from the side; that is, at the one end of the incision. The cornea is then pressed upon below the centre, so as to cause the large wound to gape considerably, and make the edge of the lens escape in front of the iris. A strong solution of pilocarpine is used immediately before operating. Needling is done a fortnight later.

The large incision which has to be made, in order to remove the lens easily and without injury to the iris, is perhaps to some extent a disadvantage. Other things being equal, the smaller the incision through which the lens is extracted the better. The site, however, at the corneo-scleral margin secures good apposition, and the large conjunctival flap provides well for the vitality of the cornea and for rapidity of healing. The incision, though large, has not, therefore, any of the objections which led to the abandonment of the old corneal flap of the earlier simple extractions.

The only serious disadvantage, then, is the difficulty of making it satisfactorily, so as to avoid getting the iris in front of the knife, and so as to secure a good conjunctival flap. This requires some practice. The knife has to be very slightly tilted, with its edge directed more backwards, so that part of its flat surface may be used to support and, as it were, press forward

and raise the cornea while the incision is being made. One is more dependent, too, upon the patient keeping the eyes quiet and not making any violent or sudden attempts at rotating them upwards. Hence the reason for cocainising well and for providing a ready object for fixation, preferably a candle flame, which can be employed even when the other eye is totally blind. If the iris does fall in front of the knife, and is cut as the incision is completed, one cannot well make the large conjunctival flap; and one is of course, in consequence, rather worse off than if one had made a smaller section and an iridectomy in the ordinary way. But this should not often happen.

The large conjunctival flap leads to a more rapid re-forming of the anterior chamber, which is generally complete in an hour or less. This cannot but be an advantage in overcoming the risks of inoculation by micro-organisms, much as rapid operating, with as little interference as possible with the wound after it is made, is to be preferred in this respect to slow deliberate cutting. It is not improbable, too, that the large, cut, lymph-exuding conjunctival surface has a valuable effect in acting as a trap, and in destroying germs which might otherwise have to be fought in the corneal wound or chamber.

To come to the question of iris prolapse. Prolapses do occur, but they occur only during, and sometimes within an hour or two after, operation, but very rarely later. Since becoming alive to this, I have made it a rule to perform iridectomy whenever the iris does not at once go back of itself or by rubbing on the cornea, or after running the shell repositor along the wound, and go back so completely as to leave a perfectly round and contracted pupil.

No doubt iridectomy at this stage will be necessary more often at the hands of one operator than of another. I have to resort to it in about one case out of ten, and I believe it is more prudent to overdo this precaution than otherwise. The eye should, in fact, always be examined in about an hour after operation. This is especially desirable where the patient has been allowed to walk from the operation table to bed. It is comparatively rare to find a prolapse then if a strong solution of pilocarpine has been used; but if found, it should be removed, and not replaced.

With these exceptions, prolapse practically does not occur. Even the risk of a slight blow to the eye, which is not so uncommon an occurrence, and which often leads to a bursting of the wound and obliteration of the chamber in the ordinary operation with iridectomy, need not be feared. The wound,

owing to the rapidity of healing of the conjunctival flap, is so much stronger that, should it give way at all, it does so over a comparatively small extent.

It may be said, If it is necessary, in order to prevent prolapse, to do iridectomy in such a considerable proportion of cases, this is surely an objection to the simple operation. And no doubt it is; it is *the* objection, far before the tendency to after-prolapse, which is practically nil, and much greater than that of the technical difficulty in performing the operation, which can be overcome.

In my experience, iritis occurs less frequently after simple than after combined extraction. Whether this is due to the absence of any wound in the iris, to the absence of any incarceration of portions of the lens capsule, or to the introduction of fewer micro-organisms into the anterior chamber, or to any or all of these imaginable causes, I am not prepared to say.

Complete freedom of the iris from any encleisis or any adhesion to the wound is much more frequent in the simple extraction by Snellen's method than when iridectomy is performed. In the combined operation one often finds some more or less marked difference in the plane of the two limbs of the coloboma, indicating adhesion.

It is this which to my mind establishes the value of a successful simple extraction, and makes it worth striving to attain, notwithstanding the disadvantages above referred to. This complete freedom of the iris can often be got, and its value is of a very different order than the purely cosmetic round pupil or the avoidance of what is sentimentally called mutilation of the iris.

If, further, one takes into consideration the rapidity of healing, the comparative freedom from iritis, and, if you will, the round pupil, one must be tempted to select cases in which there are good grounds for hoping that these advantages may be realised.

Cases of hard, nuclear, black cataract in very old people; cases of over-ripe cataract, with capsular opacities and disease of the suspensory ligament; cases where there is a very shallow anterior chamber; cases in which there is a foreign body in the lens; and cases complicated by iritic adhesions; also where one has to do with a very nervous, unruly patient — may be more suitably treated by the combined operation, with not too large an iridectomy.

Operations for after-cataract.—In a certain proportion of cases in which a cataractous lens has been removed, it becomes necessary, sooner or later, to perform some operation in order to further increase the transparency of the pupil. The proportion

of cases where this is necessary is less the more completely the cortical lens matter has been removed or afterwards absorbed. The degree of iritis, too, following the extraction is of influence in this respect. When there has been any considerable degree, a subsequent operation will always be necessary before good vision can be obtained. On the whole, a second operation is most frequently required where the first operation has been performed before the cataract has been quite ripe. The operation to be selected in any case depends upon the degree of opacity as well as upon the nature of the membrane.

The single cutting needle operation.—The operator steadies the eye with the fixation forceps, and introduces the needle through the outer or inner side of the cornea, according as the right or left eye is the one operated on. The needle is pushed obliquely inwards until its point penetrates the membrane as far over to the opposite side as is possible without wounding the iris. It is then swept round in this position, so as to cut a good opening in the membrane without penetrating deeply into the vitreous.

FIG. 96.—Small knife used for discission.

By first piercing it, the membrane comes to lie with its cut edge up against the cutting edge of the needle, and is easily divided without any traction. This operation is suitable in all cases where an operation is required, shortly after extraction, to complete the transparency of the pupil, and where there has not been so much iritis as to lead to any drawing up of the pupil. A double needle operation is often used for such cases as well; but when the membrane is tough, it is more difficult to procure in this way a satisfactory opening, a longer manipulation is necessary, and, besides this, there is liable to be a degree of dragging on the attachments of the membrane, which may lead to very considerable irritation, and the eventual closing up of the aperture. Personally, I use the single sharp needle in all cases in which iridotomy is not necessary. In needling after a simple extraction, a detachment of any synechiæ that may have formed can be made at the same time, and thus a round mobile pupil be got. When the operator has assistance, the cutting operation may be performed by oblique illumination, with the patient seated on a chair in the dark room.

The scissors operation, or iridotomy.—A good hold is taken of

the conjunctiva with the fixation forceps, and a narrow keratome introduced into the anterior chamber as near as possible to the corneo-scleral margin. The keratome may be made to pierce the iris at the same time. The incision should not be too small, as it should be large enough to enable one to use the iridotomy scissors freely ; it should therefore be at least 4 mm. at its inner opening. After the keratome has been slowly withdrawn, a pair of Wecker's iridotomy scissors are introduced. The one blade, which should be sharp-pointed, is passed well underneath the iris and membrane, and the other above them until the opposite angle

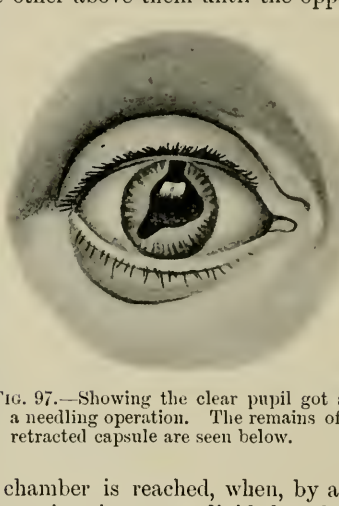


Fig. 97.—Showing the clear pupil got after a needling operation. The remains of the retracted capsule are seen below.

of the chamber is reached, when, by a firm snip, the intervening tissues are divided, and the scissors quickly withdrawn closed. The direction in which the blades of the scissors are passed should be at right angles to the stretched fibres of the iris.

This operation is suitable for most cases where the pupil has become closed and drawn up owing to iritis after extraction. The iridotomy scissors are often made too long in the blades. They should not be much larger than two-thirds the diameter of the anterior chamber, or three-eighths of an inch. The difficulty in performing the operation properly is to get the blades sufficiently separated so as to pierce through the whole thickness of the obstructing screen near enough to the side at

Fig. 98.—Iridotomy scissors, with sharp- and blunt-pointed blades.

which the section is made. It is on this account that it is advisable not to make the section too small, and at the same time to pierce the iris and subjacent membrane with the keratome.

Excision of a triangular piece of iris.—In cases where the iritis following extraction has been very severe, and where there is consequently a want of elasticity in the opaque screen, owing partly to wasting of the muscular tissue of the iris and partly to the tough nature of the plastic tissue to which it is firmly glued, the following proceeding may sometimes give a fair result:—A small flap, consisting of both cornea and iris, is made about midway between the centre and lower circumference of the cornea, but rather nearer the latter. Two converging snips

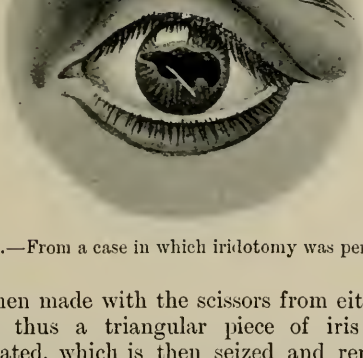


Fig. 99.—From a case in which iridotomy was performed.

upwards are then made with the scissors from either end of the iris flap, and thus a triangular piece of iris and subjacent membrane isolated, which is then seized and removed with the iris or capsule forceps. In these cases the vitreous is often much liquefied, and a considerable amount necessarily escapes during the operation, the permanent effect of which depends upon the degree of reaction following, as well as upon the clearness of the vitreous.

An absence of complete consolidation in some portion of the scar, corresponding to the line of incision for extraction of cataract, sometimes occurs, and results in a more or less pronounced cystoid swelling. This is a condition which should never be left untreated. Apart from the irritation and discomfort which it may cause, and from the greater than usual degree of

astigmatism with which it is occasionally associated, there are risks attaching to this cicatricial defect which call for interference. The cystoid cicatrix is liable to injury, and, when injured, may furnish a nidus for micro-organisms, and an entrance for them into the deeper parts of the eye, which may lead to serious destructive inflammation.

Often the condition does not develop until some time after the patient has been discharged. When the little cyst is opened into, it comparatively rarely happens that the aqueous humour is evacuated. There must therefore seldom be a direct communication between the cyst and the anterior chamber, although, no doubt, the scar tissue admits of filtration. Usually, if the

Fig. 100.—Cystoid cicatrix.

cyst has existed for some time, it is much larger than the real defect, as it is only a small portion of the underlying scar that is filtrating. Often the defective portion can be readily seen through the transparent cyst wall. It is nearly always apparent after the conjunctiva has been cut through. It is this part only that has to be attacked. The best means of doing so is with the thermo-cautery. The conjunctival wall of the cyst should first be slit up from end to end with a Graefe's knife. In doing so, the edge of the knife may be kept directed away from the cornea, so that the collapsed wall of the cyst may form a conjunctival flap. The flap, when sufficiently large, is turned down over the cornea, and the underlying tissues cleaned by a stream of sterilised water or weak sublimate lotion. Whether or not

there is then any oozing away of aqueous humour, the visibly weak portion of the scar is next touched with the fine point of a thermo-cautery, and the flap replaced without being stitched. The burning should not be deeper than to penetrate through, at most, one-half the thickness of the scar. It should have its greatest length in a line with, and not perpendicular to, the scar. A dressing may be applied for twenty-four or forty-eight hours afterwards. Occasionally this little operation may have to be repeated before the desired smooth cicatrisation is obtained.

Dislocation of the lens.—In order that the lens may be displaced, some rupture or destruction or weakening must take place in some part of the zonule of Zinn. Dislocation occurs traumatically and idiopathically; in the latter case also congenitally. Dislocation, whether traumatic or idiopathic, may be complete or partial.

A partial dislocation or subluxation of the lens exists when some portion is tilted out of position whilst the centre remains in its place. The tilting may be in any direction. The partially dislocated lens often remains clear, and the diagnosis may consequently be difficult if the degree of displacement is slight. Astigmatism following a blow on the eye may be due to a slight displacement of the lens of this nature. When the subluxation is at all marked, a pushing forwards of the iris at one portion, and a consequent shallowing of the corresponding portion of the anterior chamber, is observed, with a tremulousness of the iris in the opposite direction. There is then no difficulty in the diagnosis, especially when the pupil is well dilated, and the edge of the lens, often slightly serrated, is to be seen with the ophthalmoscope.

Complete dislocation takes place *into the vitreous*, or forwards *into the anterior chamber*, or, in case of rupture of the sclera, *subconjunctivally*. The first is the most common. The dislocation may be so complete that the lens is entirely removed from the line of sight, and lies at the bottom of the vitreous chamber, where it may remain for long transparent, though as a rule it very rapidly becomes intransparent. When the vitreous is liquid, the dislocated lens bobs up and down with the movements of the eye. More commonly the dislocation is not so complete, and then the edge of the lens can be seen with the ophthalmoscope. A traumatic dislocation is very frequently associated with a separation of the peripheral attachment of a portion of the iris (irido-dialysis), or an inversion of the iris, either complete or partial. Often in the case of idiopathic dis-

location the lens has been previously intransparent, and vision may even be improved by the dislocation.

An idiopathic dislocation (see Fig. 102) is mainly met with in cases of disease of the vitreous. The intimate connection between the zonule and the hyaline membrane of the vitreous brings about a participation of the ligament in disease of the vitreous.

Dislocation into the anterior chamber is not nearly so common. It mostly takes place in cases where the lens is small and calcareous, but full-sized transparent lenses are occasionally dislocated in this direction. They often then remain transparent or semi-transparent for a long time. In a certain proportion of cases of dislocation of the clear lens forwards there has pre-

Fig. 101.—Traumatic subluxation of lens with irregularly dilated pupil.

viously existed congenital displacement. The two forms of dislocation described are very apt to set up irritation with increased intra-ocular tension. This is most likely to occur in the traumatic cases.

As to *treatment*, interference is only called for when the condition gives rise to irritation. The dislocated lens should then be extracted. In order to do this successfully care should be taken to make a sufficiently large incision. Some vitreous generally escapes, too, but this cannot well be avoided. More difficulty is experienced sometimes in the extraction of a backwardly displaced lens. In such cases, after making a large incision, a scoop has usually to be used for removing the lens. Different methods of fixing the lens in some definite position

before extracting have been devised, but these as a rule are not necessary.

Subconjunctival dislocation is only caused traumatically. It occurs almost invariably in adults, in whom the elasticity of the sclera is less than in young individuals. As a rule, if not invariably, the rupture of the sclera and escape of the lens take place upwards, and astonishingly little reaction follows the injury. There is generally a good deal of hæmorrhage at the time, so that the parts are not well seen, but the lens is easily made out, lying below the conjunctiva. When the wound in the sclera has healed, it has a dirty bluish colour, owing to an entanglement in the cicatrix of pigment from the ciliary body and iris.

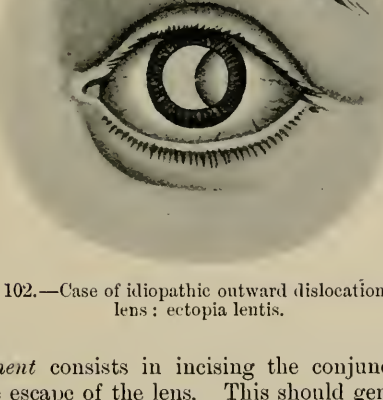


Fig. 102.—Case of idiopathic outward dislocation of the lens: ectopia lentis.

The *treatment* consists in incising the conjunctiva, so as to permit of the escape of the lens. This should generally be done as soon as possible, especially if a portion of lens is included within the lips of the wound.

Complete expulsion of the lens from the eye sometimes, though comparatively rarely, takes place as the result of accident. It is more common for it to escape through a large perforating ulcer of the cornea, after which the eye generally shrinks.

Congenital displacement of the lens, or *ectopia lentis*, occurs mostly upwards, or upwards and inwards, and upwards and outwards. It is often met with in several members of the same

family, and is hereditary. The defects of vision depend to a great extent on the amount of displacement. As a rule, the patient directs his attention either to the images formed by refraction through the lens, or to those formed by the rays which reach the retina without passing through the lens. The manner in which he sees depends partly on the extent of the displacement, and partly on the state of refraction with or without the intervention of the lens. Usually the rays passing through the lens are too strongly refracted, those passing by the side of it too weakly refracted, so that in the first case there is myopia, and in the second hypermetropia. Whether the vision is most improved by concave or convex glasses can as a rule only be determined on trial. Sometimes these prove equally

FIG. 103.—From a case of coloboma of the lens.

good, but the one produces more diplopia than the other. On the whole, the uniocular diplopia to which the condition gives rise is more evident when the refraction is corrected than when no glass is worn. The improvement in vision is, however, in some cases very great, and the diplopia soon ceases to cause any annoyance.

Ectopia is due to a faulty development of one portion of the zonule. It probably always occurs in both eyes, and is frequently associated with a defect in the power of convergence. A traumatic dislocation into the anterior chamber is more likely to occur where there is a congenital displacement than where the lens is in its normal situation. Notwithstanding the displacement, the lenses remain transparent throughout life.

Two very much rarer malformations of the lenticular system are met with:—(1) *Coloboma lentis*, or a defect in the lens. This only occurs in cases where a large and continuous coloboma exists of the choroid as well. And (2) what has been called *Lenticonus*, and described as a conical protrusion of the lens, very much resembling keratoconus. In lenticonus we find, on illuminating the pupil with the ophthalmoscope, that every movement of the mirror causes crescentic lights and shadows to play round an enclosed circular area. Within this area, which is smaller than the pupil, retinoscopic shadows show myopia. Outside it there may be, and generally is found to be, hypermetropia. This appearance is apparently sometimes due to an unusual amount of sclerosis of the lens nucleus, which may be the cause of considerable visual defect.

CHAPTER VIII.

DISEASES OF THE RETINA AND OPTIC NERVE.

Diseases of the Retina.

Very considerable physiological differences exist in the degree of vascularity of the retina,—that is, in the degree shown by the colour and appearance of the vessels. On this account, and also because the ophthalmoscopic magnification is not sufficiently great for the detection of small differences in the size of the vessels, it is impossible to draw a hard-and-fast line between the normal state, and deviations in the direction of anæmia on the one hand, and hyperæmia on the other. For these reasons, too, as well as for others connected with peculiarities of the intra-ocular circulation, the observed condition of the retinal vessels does not afford by any means as delicate an indication, either of the state of the cerebral circulation, or of the heart, as might be, and indeed has been, supposed.

When there is increased afflux of blood to the brain without collateral hyperæmia, a similar afflux must take place to the ocular vessels. A passive hyperæmia of the brain, owing to impeded venous circulation, need not, however, affect the eye, as the ocular veins have other channels into which they can empty themselves besides the cerebral sinus, a thrombosis of which might therefore occur without influencing the circulation within the eye. When the venous impediment lies farther off,—in the jugular vein or in the thorax,—there will be at the same time a visible interruption in the circulation within the eye. Interruption in the carotid circulation affects the eyes, although the anæmia which this causes may not be apparent. In aortic stenosis, for instance, by maintaining pressure with the finger on the eye while examining with the ophthalmoscope, the prolonged wave of pulsation can be well seen and distinguished from the sharp beat which occurs under similar circumstances in normal conditions of the circulation. In aortic regurgitation there may

or may not be spontaneous pulsation of the retinal artery and vein. This depends on the degree of compensation, or on whether or not there are other complications; if the mitral is also affected there is usually no pulsation.

Venous pulsation is often seen, and most frequently on the disc. It is not necessarily indicative of any pathological condition. It usually, indeed, depends upon some interruption in the vessel itself, where it bends suddenly round an artery or some part of the nerve.

Spontaneous *arterial pulsation* is pathological, and indicative either of some general circulatory disturbance, sometimes only increased cardiac action, or of increased intra-ocular tension. When there is increased tension alone, what is seen is a quick flash of blood rapidly distending one or more of the more or less collapsed arterial trunks on the disc, synchronously with each heart-beat. On the other hand, the pulsation sometimes, seen where there is some diseased condition of the aortic valve, is a comparatively gradual dilatation of the artery, producing often at the same time a visible movement of the vessel. This form of pulsation, too, is not confined to the trunks on the disc, but is often more distinctly seen at other parts, particularly where the vessels divide or make sharp turns.

Vascular changes in the brain need only appear simultaneously in the eye when the cause of such changes is a central one,—that is, due to irritation or paralysis of the vasomotor centre in the medulla. An increase or diminution in the amount of cerebro-spinal fluid, giving rise to altered conditions of the brain, need not affect the circulation in the eye, though such conditions may be followed by other ophthalmoscopic changes.

The streak of reflection along the arteries is brighter the lighter the colour of the blood. Any marked œdematous condition of the retina, such as that which occurs from embolism of the central artery or commotio retinæ, causes the streak of reflection to disappear more or less completely. It is absent, too, in detachment of the retina.

Alterations in the *size* of the vessels occur in disease. Both arteries and veins may be either enlarged or diminished. It is most common, however, to find the calibre of the veins increased and that of the arteries diminished. Indeed, most inflammations of the retina cause this. Owing to localised phlebitis, some only of the retinal veins may be enlarged, and that often in an extreme degree. It is rare to find the arteries increased in size, whilst diminution in the size of the veins is only met with in the subsequent atrophic stages of retinal inflammation.

Sometimes, though very rarely, a formation of new vessels is seen to have taken place in the retina. Usually this, when it happens, is part of the process of organisation of an old blood clot. More frequently there may be seen leashes of small vessels passing into the vitreous and springing from the retinal vessels.

The retinal vessels seem to be very little liable to aneurysm.

Hyperæmia of the retina.—As has already been said, it is not always quite easy to say that the apparent congestion in any particular case exceeds the bounds of physiological variation. In coming to a conclusion on this point, it is well to pay attention to the relative sizes of arteries and veins. The calibre of a retinal artery is never, under altogether normal conditions, much less than three-quarters that of the corresponding vein.

Hyperæmia in the retina, as elsewhere, may be active or passive. An *active hyperæmia* may be set up by all such conditions as call for any unusual straining of the eyes, such as reading in the dark, or prolonged attempts at deciphering difficult manuscript or bad print. And this form of strain may be favoured, and more readily lead to congestion, when there is either some general weakness or some marked error of refraction which renders persistent exercise of this nature more irksome. As the normal relation in the size of the artery and vein is pretty well maintained in active hyperæmia, the diagnosis depends greatly on observing the state of congestion of the optic disc, which in such cases does not show so marked a contrast in colour from the surrounding fundus as is usual. At the same time, however, there is no indistinctness of its margins, such as occurs when inflammatory swelling of the papilla takes place. The cause of the deeper coloration of the disc is of course the springing more into view of the smaller vessels.

Passive hyperæmia, on the other hand, being due to some interference in the venous circulation, or in both venous and arterial circulation, gives rise to an abnormal relation in the size of arteries and veins. The veins are increased in size, sometimes to an excessive degree, while the arteries either retain their normal size or become diminished. The interruption to the circulation may be in the eye, as in glaucoma, or it may be external to it,—produced, for instance, by pressure on the optic nerve. Congested retinal vessels have not only their calibre increased, but are also lengthened. On this account they take a more tortuous course than normal, the tortuosity being greater at right angles to the retinal surface than in the surface of the retina itself. Contiguous portions of a vessel may therefore lie

at different levels, and consequently not be in accurate focus at the same time. This undulatory shape causes the blood in some parts of a vein to appear darker than at others, and this difference in the apparent depth of colour in different sections of the vessel is often enhanced by a simultaneous swelling and intransparency of the retina. Great tortuosity in the plane of the retina is most frequently only a congenital peculiarity.

Anæmia of the retina.—Some of the general conditions which are associated with anæmia of the retina have already been referred to. The changes are not sufficiently marked, as a rule, to afford any important evidence of the existence of anæmia of the brain, and indeed most cases of general anæmia are not associated with any marked ischæmia of the retina. Anæmia, too, from excessive loss of blood, only produces temporary ischæmia of the retina. The ophthalmoscopic appearances met with in pronounced cases of ischæmia are great pallor of the disc and narrowing of the lumen of the vessels. There are, besides, altogether fewer retinal vessels visible over the fundus.

Ischæmia of the retina may be functional, when it is due to vasomotor constriction; or toxic, the effect of the poison being of the same nature, namely, causing constriction of the vessels by some irritation of the vasomotor centre. A most marked and not apparently very infrequent example of toxic ischæmia is that produced by overdoses of quinine.

Much the more common form of ischæmia is, however, the atrophic, which occurs after optic neuritis, essential atrophy of the optic nerve, and inflammatory and other degenerative changes in the retina. Ischæmia is also more or less marked in cases of embolism of the central artery of the retina.

Retinal hæmorrhages.—Hæmorrhage from the retinal vessels is by no means an uncommon occurrence. The causes of hæmorrhage may be: hyperæmia, both active and passive; atheroma of the blood vessels generally, as well as other local disease of the choroidal and retinal vessels; many different conditions in which the constitution of the blood is altered; and traumata. The ophthalmoscopic appearances of hæmorrhages differ, as well as the degree of visual disturbances produced, according to their position and extent.

Hæmorrhages are frequent in all cases where there is retinitis. Of circulatory disturbances apt to be accompanied by retinal hæmorrhages may be mentioned: embolism of the central artery and thrombosis of the central vein, as well as, probably, sudden compression of the central vessels by hæmorrhage into

the sheath of the optic nerve; glaucoma; and the altered tension which follows iridectomy for that disease. Of diseased conditions of the blood, again, which may lead to retinal hæmorrhages, the following may be noted: pernicious anæmia, albuminuria, diabetes, some forms of poisoning, purpura, and septicæmia.

The bleeding may be confined to the retina itself, or it may pass backwards and cause separation of the retina from the choroid, or forwards into the vitreous. This last result is not common, and only likely to take place when a large trunk is

Fig. 104.—Retinal hæmorrhages.

ruptured by accident or disease. Hæmorrhagic detachment of the retina is almost invariably traumatic. It occurs in cases where, with a tendency at anyrate to hæmorrhage, owing to an altered state of the vessels, the intra-ocular tension is suddenly lowered by the escape of some of the contents of the globe. It occurs, for instance,—fortunately only very rarely, however,—after cataract extraction. It is much more frequent after iridectomy for glaucoma.

Hæmorrhages into the retina usually lie in close proximity to the vessels. When situated in the layer of the nerve fibres,

which is very often the case, as it is in this layer that the larger vessels course, they have a tendency to be elongated in shape, with sharply defined sides and irregular radiating ends. This form of retinal hæmorrhage is distinguished as a *flame-shaped hæmorrhage*. The peculiar shape is occasioned by the direction of the nerve fibres between which the blood settles and is constrained to pass. Only larger hæmorrhages in this part of the retina can assume a more irregular form, the extent of the extravasation being then sufficient to overcome the resistance of the nerve fibres, which are pushed aside or ruptured. Deeper hæmorrhages in the retina are circular or irregular in shape, with a tendency rather to pass backwards than to spread superficially, owing to the resistance offered by the connective tissue fibres of Müller.

Hæmorrhages when numerous are usually found in the neighbourhood of the large vessels; mostly, therefore, near the disc. Frequently they are distributed in a radial manner round the disc. Less numerous hæmorrhages are not infrequently found in the region of the macula. Often, indeed, there is only a single, and, it may be, quite a small, hæmorrhage in this situation. Occasionally a few hæmorrhages may be seen confined to some particular part of the fundus. It is not always easy to detect the reason for this, but sometimes it is due to localised phlebitis and thrombosis.

The subjective symptoms to which hæmorrhages into the retina, unassociated with retinitis, give rise, depend on their position and extent. When they are peripheral there are no evident symptoms, although if large there will be found to be a corresponding defect in the field of vision. When occurring at or near the macula they give rise to a positive scotoma, and sometimes to coloured vision. Thus, when fresh, patients may complain of seeing a reddish cloud, which afterwards appears greenish, in front of their eyes. The objects seen in the region of the scotoma as it clears away may appear distorted,—that is, the patient may be conscious of more or less *metamorphopsia*.

Smaller retinal hæmorrhages are generally absorbed without leaving any trace and without undergoing any discoloration. Larger hæmorrhages generally leave some trace in the shape of degenerated patches, in which cholesterin occasionally forms, and gives rise to a very brilliant reflection. The appearances, therefore, of old hæmorrhagic spots as seen with the ophthalmoscope are very various. They may be mere patches of greater or less depigmentation revealing the choroidal structure behind. Or again, they may be yellowish-white or white, sometimes

glistening white. These straw-coloured or white patches are often bordered by, and here and there covered by, masses of pigment. Patches of this kind are the remains of hæmorrhages into the deeper layers of the retina. Finally, there may be nothing but irregular pigment spots left, which are usually considerably smaller than the original extravasations.

Retinal hæmorrhages in old people, if due to an atheromatous condition of the vessels, may be followed by glaucoma. The

FIG. 105.—Post-hæmorrhagic development of fibrous tissue in the superficial layers of the retina, showing irregularly arched manner in which this change usually takes place.—After WECKER and MASSELON.

prognosis is then bad not only for vision, but also with respect to other apoplexies which may endanger life.

Subhyaloid hæmorrhage.—A somewhat rare occurrence, and one which gives rise to a very characteristic ophthalmoscopic appearance, is for an effusion of blood from the retina to spread out in a thin layer between the retina and the vitreous without passing into the latter. This all but invariably occurs at or near the centre, so that the macula is covered by a patch three or four times the diameter of the papilla. This patch of effused

blood is at first dark red, with sharply-defined curved margins. After a short time it begins to undergo absorption from above, so that the line between the partially absorbed portion and that in which the blood is still present is perfectly straight and horizontal. A hæmorrhage of this nature causes a dense central scotoma, which passes off, either entirely or nearly so, after the lapse of some time. The prognosis, so far as the restoration of vision is concerned, is therefore good.

Retinitis.—Inflammation of the retina occurs along with

FIG. 106.—From a case of sub-hyaloid hæmorrhage which has undergone partial absorption ; inverted image.

choroiditis and cyclitis, whether set up traumatically, sympathetically, or otherwise. Besides this inflammation, which is for the most part an extension from the other membranes, a primary retinitis is met with in many diseases in which there is an altered state of the blood or the blood vessels. Of such may be mentioned septic processes and others which lead to thrombosis, syphilis, albuminuria, diabetes, and various forms of anæmia, possibly also oxaluria.

Prolonged exposure to strong light, excessive straining of the eyes in bad light, etc., in fact everything which leads to active

congestion of the retina, while it no doubt favours the occurrence of inflammation under conditions in which it is likely to be met with, does not of itself suffice to set it up, and must be looked upon therefore as only of secondary importance in the etiology of retinitis.

Hæmorrhagic retinitis.—Many forms of retinitis are hæmorrhagic; that is to say, the changes in the retina are associated with hæmorrhages from the vessels. Only cases in which the number of hæmorrhages is very great and spread over the whole of the retina can be properly termed hæmorrhagic, as distinguished from other forms.

The term is rightly applied when the extravasations constitute a more important feature than the other changes, such as swelling of the papilla and retina, or the occurrence of patches of fatty degeneration in the retina, and where diseases of the kidneys and diabetes can be excluded. Retinitis, with abundant hæmorrhages occurring in one eye alone, is almost invariably of this nature. A greater or less extent of the retina may be covered by hæmorrhages, most of which are flame-shaped, and therefore superficial, though some are more irregular and deeper. Sometimes there is a hæmorrhagic extravasation into the vitreous, causing opacities in it. The retina itself has often a dull intransparent look, more especially around the disc. This appearance is produced by œdema. Patches of opacity, such as occur in other forms of retinitis, are sometimes seen, but they are insignificant in amount compared with the hæmorrhages. Their distribution, like that of the hæmorrhages, is radial. The disc, although its margins may be completely obliterated, is not swollen and prominent as in papillitis. More or less atrophy of the disc always comes on after some time has elapsed. The veins are greatly engorged and tortuous, the arteries usually narrowed and more or less invisible. White streaks are often seen to accompany the veins. Occasionally the whole visible parts or portions of the venous trunks are converted into white lines. This latter appearance is always met with where the hæmorrhages are confined to some particular sector of the retina. Hæmorrhagic retinitis practically never occurs in both eyes. The cause is venous thrombosis, the result of phlebitis, which is no doubt sometimes arthritic.

While the central vision is as a rule very greatly reduced, the extent of the field of vision may not be at all restricted. After some time the atrophic changes which usually take place leave the vessels narrowed and obliterated, the disc pale, and the field of vision concentrically limited, just as in atrophy of the optic

nerve. Eventually the vision may be completely lost. The prognosis is certainly, therefore, extremely bad in the worst cases.

No *treatment* is likely to be of much good. The eyes should be shaded from strong light, and reading or writing avoided as much as possible, attention being at the same time paid to the general health of the patient.

Albuminuric retinitis. — A certain proportion of cases of Bright's disease, variously estimated at from ten to twenty per

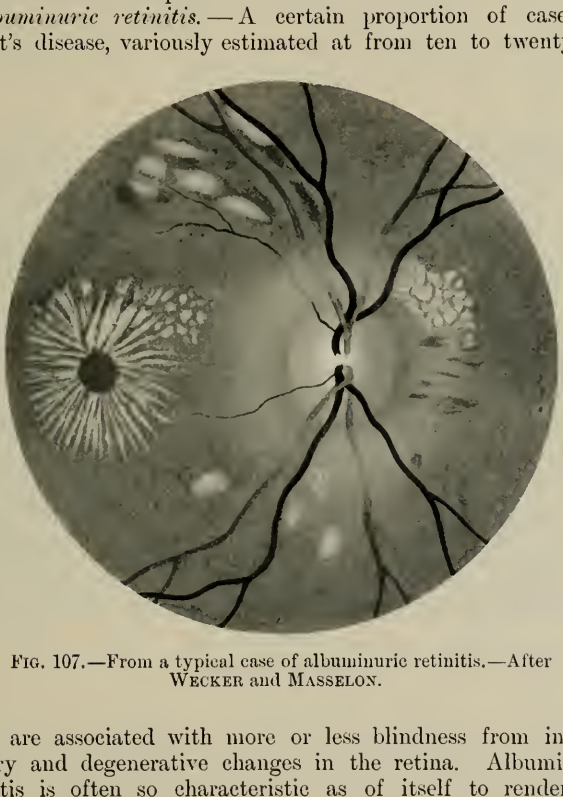


Fig. 107.—From a typical case of albuminuric retinitis.—After Wecker and Masselon.

cent., are associated with more or less blindness from inflammatory and degenerative changes in the retina. Albuminuric retinitis is often so characteristic as of itself to render the diagnosis of kidney disease all but certain. At other times a retinal inflammation of undoubtedly albuminuric causation may not present symptoms which are at all characteristic.

The ophthalmoscopic appearances in albuminuric retinitis (Fig. 107) are, speaking generally, more or less hyperæmia and swelling of the papilla; slight increase in the calibre of the

veins and diminution in that of the arteries; and diffuse opacity of the retina, with hæmorrhages, and the formation of white patches, which are confined at first to the region of the posterior pole. The changes in the papilla are at first very slight, and there is some opacity of the retina, and a few hæmorrhages in the part surrounding the papilla. The hæmorrhages, too, are mostly deep and round, less frequently flame-shaped. This appearance is of itself suggestive of the kidneys being the cause, but it is not absolutely characteristic. At a later stage white, and for the most part deep-seated, patches of fattily degenerated exudation make their appearance in the retina, while at the same time there is often some swelling added to the hyperæmia of the papilla. These white patches are mostly found in the region of the macula, where they are arranged in a star-shaped form, radiating out from the fovea. Around this central figure there are often a number of scattered spots of a similar nature. Such spots, too, are frequently to be seen in other parts of the fundus, surrounding, and never at a very great distance from, the disc. In some cases the patches round the disc become confluent, and thus form an extensive white area or circumpapillary zone, stretching up to the disc on all sides, and with an irregular margin towards the more healthy retina. Extensive offshoots from this zone then generally accompany the larger vessels. The vessels in the circumpapillary exudation are seen to be large and tortuous, and are here and there altogether masked by it. The retina is thickened, and there are usually large and numerous hæmorrhages in the swollen white area. There is never any opacity of the vitreous. When these appearances are met with, they may be looked upon as practically characteristic of albuminuria.

Little alteration may take place in the ophthalmoscopic picture, even after a considerable time has elapsed. The patches and hæmorrhages may slowly clear away, or fresh ones become deposited. At an advanced stage of the disease the spots are sometimes very thickly scattered over the fundus, and here and there, more especially at the centre, a dirty greyish diffuse pigmentation may develop in them. Occasionally, too, the white reflection from the patches becomes intensely brilliant and metallic looking, owing to the development in them of cholesterin. At the same time the papilla and the retina may be very greatly swollen, so that at places the vessels entirely disappear from view. The retinal swelling sometimes gives rise to an appearance not unlike detachment.

Most of the white patches lie in the deeper layers of the

retina, the vessels of which may be seen to pass over them at places. Others are more superficial, and more or less completely obscure portions of the vessels. Almost invariably both eyes are affected at or about the same time.

The degree of blindness produced by albuminuric retinitis varies very much, and depends on the extent of the pathological changes at the macula. There is therefore often considerable difference in the visual acuity of the two eyes. The disease rarely causes complete blindness, but most frequently produces so much defect as to render reading impossible. The field

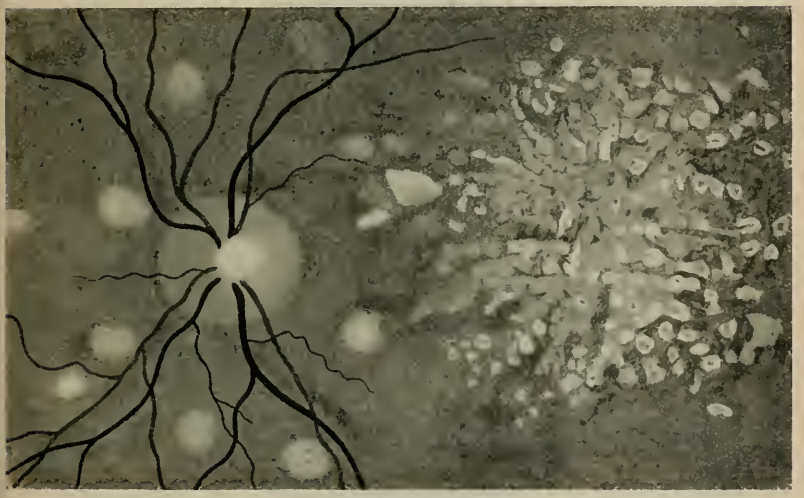


Fig. 108.—Extensive retinal changes in a case of albuminuric retinitis at a late stage.

of vision remains good, and also the colour vision. Sometimes the amount of visual defect does not correspond with, but is greater than can be accounted for by, the retinal changes. In such cases there may possibly be uræmic poisoning of the visual centres. I have seen occasionally very marked deterioration occur without any apparent increase in the retinitis, followed after a few days by improvement.

The *prognosis* in this disease is altogether gloomy, except in cases such as the albuminuria of pregnancy, where the condition may be transitory. Some cases improve so as eventually to

recover useful vision. Most remain pretty stationary, and die not long, generally not more than two years, after the onset of the retinitis. An extremely grave symptom is apparent detachment of the retina.

Albuminuric retinitis is mostly met with in chronic cases of nephritis. As the general symptoms are then often little marked, it not infrequently happens that the diagnosis is first made with the ophthalmoscope.

The *treatment* must be directed to the general disease which

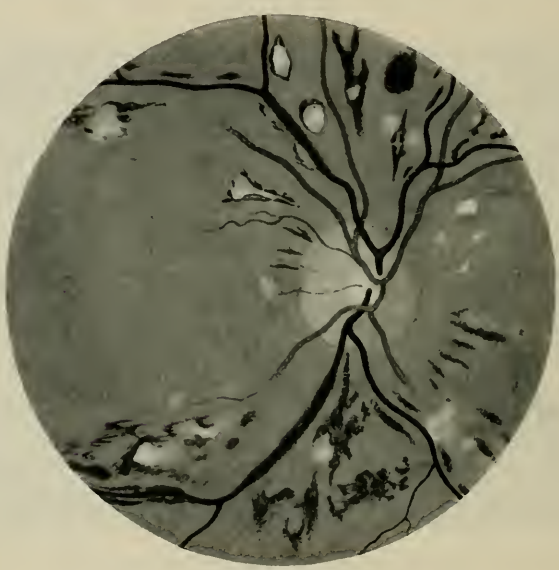


Fig. 109.—Diabetic retinitis, showing scattered exudations and hæmorrhages.—After Wecker and Masselon.

is the cause of the eye symptoms, the main indication being to relieve the kidneys by promoting the action of the bowels and skin. At the same time the usual precautions necessary in all deep-seated inflammations of the eye must be taken, namely, shading from strong light and the avoidance of reading.

Retinitis in diabetes.—In some cases of diabetes, mostly those of a severe type, there is a complication with retinitis. Diabetic retinitis is, however, rare when compared with the albuminuric form. Only when there is no albuminuria can the retinal

changes be safely ascribed to other conditions of the blood more directly connected with diabetes. The form of inflammation is not characteristic, and very much resembles albuminuric retinitis, being, however, less severe, or at all events accompanied by less marked changes at the macula. The amblyopia produced varies very much from a slight defect of vision to complete blindness. The latter is due apparently only to complications: extensive hæmorrhages into the vitreous or glaucoma. Opacities in the vitreous are frequent. The *prognosis*, owing to the kind of case liable to be complicated by retinitis, is almost invariably bad.

Retinitis pigmentosa.—A not very rare disease, the essential nature of which is, more correctly speaking, a sclerosis and pigmentary degeneration of the retina than an inflammation, has received the name of retinitis pigmentosa. The disease is not associated with pigmentary alterations until it has advanced to a certain stage, and the pigmentation may indeed occasionally never make its appearance at all.

Apart from the ophthalmoscopic changes, which are usually very characteristic, retinitis pigmentosa is accompanied by very definite subjective symptoms. These are — night blindness, which has usually begun in early childhood, and concentric limitation of the field of vision, with relatively good central vision.

The ophthalmoscopic changes are—a very equable, greyish pallor of the papilla; more or less marked narrowing of the vessels, both arteries and veins; usually a conspicuous defect in the pigment of the hexagonal cells, which allows the choroidal vessels, with their pigmented interspaces, to come into view; and a peculiar fine pigmentation in the retina. This pigmentation takes the form of intensely black bone-corpuscle-shaped patches, usually in close proximity to the vessels, and lying well forward in the retina (see Fig. 110). The pigmentation occurs mainly in a zone which lies midway between the centre and the periphery, and which is equally broad throughout. The breadth of the zone varies very much, being as a rule broader the more advanced and complete the sclerosis is. It generally approaches nearer the papilla on the inner than on the outer side, and in some cases patches may be seen quite up to the papilla. When very numerous, the thin filamentous processes of the pigment spots meet or come so close together as to form a network. The pigment comes from the layer of hexagonal cells, but is probably increased in amount by proliferation.

The manner in which the vision is affected by this disease varies somewhat in different cases. As a rule, while there is a

pretty marked and sometimes excessive constriction of the field of vision, the central vision remains good enough for most purposes,—for reading fine print, etc.,—yet it is only rarely that there is full normal vision. Usually the smaller the field of vision retained, the worse is the central vision. It is only comparatively rarely that very small fields with good central vision are found, and in such the restriction may be observed to slowly increase without any marked difference in the central vision. Eventually blindness generally supervenes after the

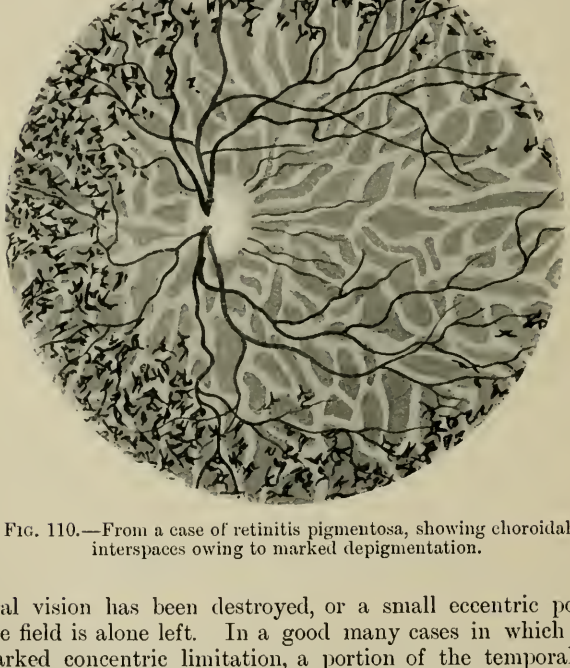


FIG. 110.—From a case of retinitis pigmentosa, showing choroidal interspaces owing to marked depigmentation.

central vision has been destroyed, or a small eccentric portion of the field is alone left. In a good many cases in which there is marked concentric limitation, a portion of the temporal part of the field of vision towards the normal periphery may be found to have still retained some vision. Occasionally, too, a zone at the extreme periphery is left more or less unaffected, so that there is a broad band of the blindness, or a ring-shaped scotoma. Occasionally the pigmentation is almost confined to the macula, and there is then a central scotoma.

Altogether the pigmentation must be looked upon as having a subordinate significance in the changes which characterise this disease. The degree of blindness cannot be inferred from the extent of pigmentation. On the other hand, the pigment is only met with in places where the sclerosis of the retinal connective tissue, which is the essential factor, has taken place. Yet there may be a sclerosis in parts of the retina where no abnormal pigmentation or depigmentation is visible. This is the case mostly in the central portions of the retina. The process of

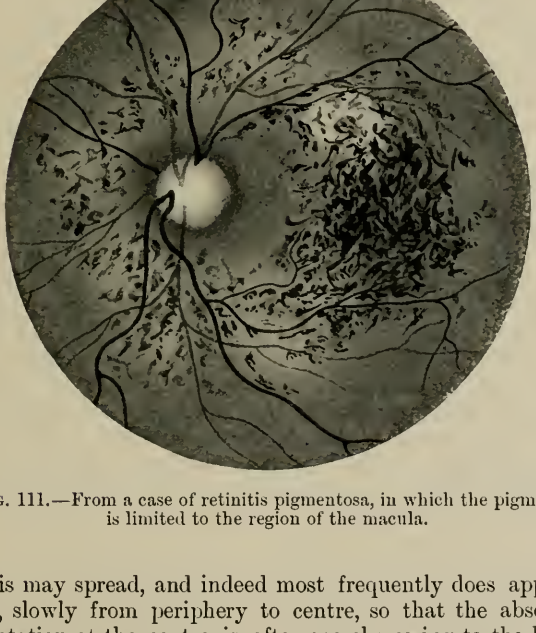


FIG. 111.—From a case of retinitis pigmentosa, in which the pigment is limited to the region of the macula.

sclerosis may spread, and indeed most frequently does appear to spread, slowly from periphery to centre, so that the absence of pigmentation at the centre is often merely owing to the less extensive alteration of the connective tissue there. In accordance with this, the central vision is relatively greatly better than the peripheral. But the presence of very constricted vessels and of great visual defect may be found with only peripheral pigmentation.

The pigment has been proved to come only from that contained in the retinal pigment cells, in which, as one part of the

degenerative process, a depigmentation has taken place. But there is no constant relation between this depigmentation and the amount of abnormal pigmentary deposition. This is very evident from the great differences seen with the ophthalmoscope (cf., *e.g.*, Figs. 110 and 111). The depigmentation is merely an atrophy of the retinal pigment, the abnormal deposition an attraction of the hyperplastic connective tissue for the pigment which, probably to some extent, proliferates (though this is not certain) in the new situation. The two processes are to a great extent independent, though primarily occasioned by the same cause,—the sclerosis,—by which, too, the nerve elements, but not, or to a less extent, the nerve fibres, are destroyed.

The restriction of the field ordinarily met with causes some difficulty in moving about, as patients with this defect are in much the same position as anyone looking through tubes held in front of either eye would be. Thus children frequently fall over things at their feet in a manner which to their parents appears, from their good vision otherwise, to be strange. The colour vision is good in retinitis pigmentosa, even in cases where the fields are very greatly restricted.

The light sense is affected both with respect to the appreciation of differences of intensity of illumination and to the vision in subdued light. The defect is most common and always most marked in the latter respect. It is this which causes the *night blindness*, which is a very early and very constant, though by no means invariable, symptom. Different degrees of the defect are met with. Often while the vision is so good in daylight as to cause no sort of discomfort, the patient is unable to guide himself in the dusk, when the light is not so far reduced as to make any very appreciable difference to the normal eye. This defect is often popularly called "twilight blindness." Things are seen by artificial light only when pretty strongly illuminated; thus while an individual might be able to read by the light of a candle, the surrounding objects in the room, which were only feebly illuminated, might be more or less invisible to him.

In many cases the defect of vision produced by feeble illumination, though pronounced, is not nearly so bad as that just described, whilst in some it is hardly, if at all, noticeable.

A form of stationary or very slowly progressive posterior polar cortical cataract is a pretty frequent accompaniment of retinitis pigmentosa. In the typical cases there appear to be no further complications; only where much the same retinal changes are met with, following inflammation from acquired or inherited syphilis, may there be more or less manifest altera-

tions in the choroid, or iris as well. In such cases, too, the retinal pigmentation is rarely if ever so equally distributed as in the true disease.

There is sometimes a little difficulty in distinguishing between cases of primary retinal sclerosis with pigmentation, and pigmentation of the retina which is secondary to choroiditis. Some cases of retinitis pigmentosa are atypical with respect to the picture presented by the pigmentation. The patches, instead of being more or less closely placed or interlaced, bone-corpuscle-shaped, and following the course of the blood vessels and capillaries, are in the form of irregular, roundish, small masses, distributed, apparently without any definite arrangement, in the deeper parts of the retina. The only difference in the pathology of those cases seems to be that the sclerosis and imbibition of pigment is more confined to the connective tissue framework of the retina, and less marked in the perivascular connective tissue, than is mostly characteristic of the process. In other respects, and especially in the absence of any choroidal changes, there is no reason why such cases should be mistaken for later stages of choroidal inflammations.

Retinitis pigmentosa is almost invariably bilateral. The disease begins either congenitally or in early childhood; occasionally not till some years after puberty. Some cases of congenital blindness, too, appear to be of the same nature. The pigmentation is probably never met with at birth, but usually makes its appearance during the first few years of life. The disease is considerably more frequent in the male than in the female sex. It is unquestionably hereditary, and, just as in all other affections where this is the case, there is often consanguinity in the parents or grandparents. Often several members of the same family are affected, rarely if ever all. Congenital deaf-mutism and idiocy are not seldom met with in the subjects of retinitis pigmentosa. Sometimes deafness comes on later.

The cause of the disease is altogether unknown. The fact that very similar appearances follow syphilitic inflammation is certainly suggestive of syphilis as a cause; yet it appears pretty certain that this is not the case. Most cases progress exceedingly slowly, and even remain for longer or shorter periods apparently absolutely stationary. No *treatment* that has hitherto been tried can be said to be of the slightest avail.

Atypical forms of retinal sclerosis occur. There are, *e.g.*, cases in which, along with an absence of any characteristic pigmentary changes, the appearance of the papilla, as well as the sub-

jective symptoms, are identical with what is found in retinitis pigmentosa.

Congenital pigmentation of the retina.—A peculiar form of

FIG. 112.—Congenital pigmentation of the retina (from a case of Mr. Sydney Stephenson's).

retinal pigmentation, which appears to be congenital, is sometimes met with. In these cases small irregularly-shaped groups of pigment occupy some sector of the retina.

Retinitis proliferans.—This name has been given by Manz

to a very unusual form of chronic inflammation of the retina.

After a longer or shorter period of defective vision, the apparent cause of which is hæmorrhagic opacity of the vitreous, there may be seen, covering more or less completely the papilla and extending over the surrounding retina, a markedly prominent and deeply folded or furrowed bluish opacity. This fibrous or membranous looking opacity follows the course of the large vessels, which it to a great extent hides, but in the furrows may be seen vessels apparently newly formed. In the region about the main mass of connective tissue which this central opacity represents, may generally be seen whitish thread-like opacities stretching farther towards the periphery of the retina. These are no doubt vessels surrounded by a dense opacity caused by perivasculitis. Hæmorrhages into the vitreous seem always to accompany this affection; and these, along with the cataract, which may subsequently make its appearance, make the image which it is possible to obtain with the ophthalmoscope as a rule not very distinct. No treatment can be said to be of any use.

Embolism of the central artery of the retina.—It is only rarely that the circulation is completely stopped in the retinal vessels; when this is the case, no pulsation can be obtained in the artery by pressure on the eye. The diminished supply of blood flowing into the eye causes the arteries to appear smaller, while at the same time the streak of reflected light along them becomes less apparent, or is altogether absent. The veins, too, may be smaller than normal, though this is usually the case only with those portions which are on and near the disc. They are often rather distended farther towards the periphery, and taper towards the disc. The ischæmia is rendered further apparent, too, by the invisibility of the smaller vessels. What looks like, and is often described as, spontaneous pulsation may be seen in the arteries, due to the partial interruption of the blood flowing into them, producing with every systole a more or less marked difference in the degree of their distension. The intermittent passage of broken columns of blood may sometimes be observed in the veins when the circulation is not altogether, but all but, stopped.

Besides the varying appearances met with in the vessels indicative of circulatory impediments, an embolism of the central artery produces other and more characteristic changes in the retina. These, however, last only a short time. The central portion presents a whitish opaque appearance, not unlike the bloom on fruit. This appearance is due to œdema. It is most

intense round the macula and optic nerve, and often indeed hardly appreciable elsewhere. As a rule, too, in the area occupied by the œdema it does not present an equal density or opacity throughout, but the whiteness tends to fade off at about equal distances from the papilla and macula. Thus, midway between the macula and the disc, it is seldom if ever so dense as in the vicinity of either. The œdema has, too, a more streaky appearance round the disc. At the centre of the macula, and corresponding in position to the fovea centralis, there is no opacity. Owing to this, the appearance presented by this portion of the retina is very remarkable, and generally described

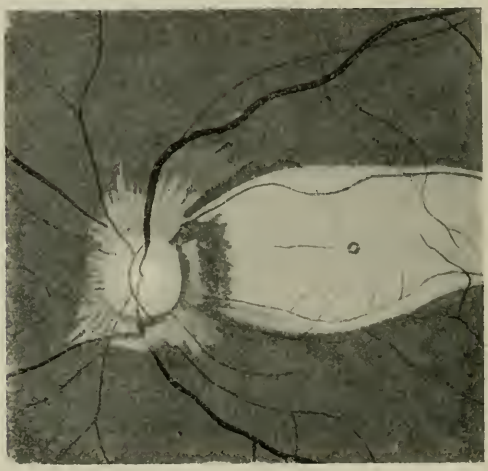


FIG. 113.—From a case of embolism of the central artery of the retina.—After JAEGER.

as a *cherry red spot*. So strong is the contrast between the colour of the fovea and the surrounding retina, that this appearance cannot fail to at once attract attention. The cherry red spot in the middle of the œdematous opaque retina, when taken along with the history of sudden and spontaneous loss of sight, is perfectly characteristic of an interruption in the circulation.

Whether the interruption in the circulation in any given case is due to embolism of the artery, or to thrombosis in the vein, or hæmorrhage into the sheath of the nerve, causing compression of the nerve and vessels, is not always easy to determine. The

subjective symptoms are the same in all causes of interruption. Hæmorrhages are much more numerous in cases of thrombosis than they are where the interruption is embolic.

The œdema of the retina does not come on immediately on the plugging of the vessels, and takes several hours, or even a day or two, to reach its height. It then slowly passes off, leaving no trace after a week or two. The diagnosis may not then be so easy unless the appearances in the vessels are marked.

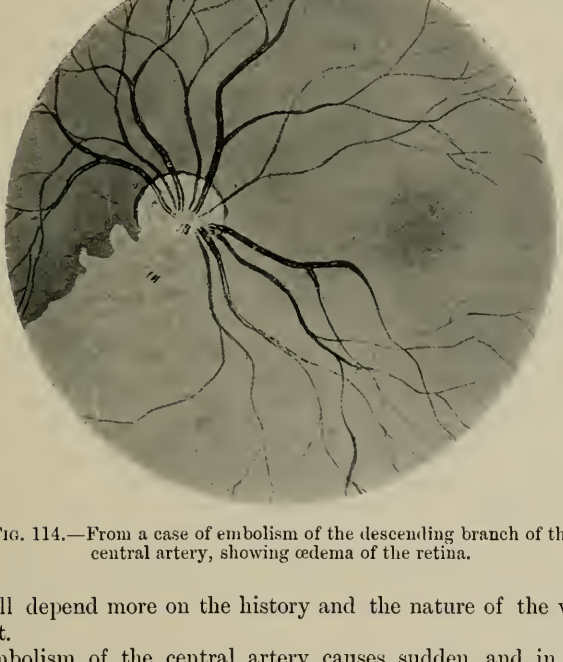


Fig. 114.—From a case of embolism of the descending branch of the central artery, showing œdema of the retina.

It will depend more on the history and the nature of the visual defect.

Embolism of the central artery causes sudden, and in most cases all but complete, and permanent blindness.

The suddenness of the blindness produced by the cutting off of the blood supply to the retina is a remarkable illustration of the close dependence of its functional activity on its blood supply. The absence of anastomosis with other trunks, too, is the cause of the blindness remaining permanent, so that only where the plugging is incomplete from the first can any sub-

sequent improvement be looked for. In a number of cases a small portion of the temporal side of the field of vision retains some vision.

Occasionally the embolism, instead of settling in the main trunk, may plug one of the branches of the central artery. There is then produced a defect in the field of vision corresponding to the portion of retina supplied by the plugged vessel. This is a much rarer accident than embolism of the trunk. In most cases that I have seen, a portion of the field has been permanently lost right up to the periphery, and a sharp line of demarcation has existed between the blind and seeing areas, with retention of sharp central vision. The corresponding artery has also been visibly constricted, or even practically obliterated. It is possible that this appearance may sometimes be due to localised spasmodic constriction of retinal arteries.

Probably in most cases of embolism there is some affection of the heart, but it is not always possible to diagnose this with certainty. Both eyes are never blinded at the same time, and cases in which the accident happens first in one and then in the other are of extreme rarity.

While the *prognosis* is therefore absolutely bad as regards the affected eye, the other may be looked upon as perfectly safe. There is more danger of embolism occurring elsewhere, and leading to other paralysis.

Very little can be done in the way of *treatment* for embolism in the retinal arteries. Kneading or massage of the eye is recommended, and is said to have dislodged the clot and led to improvement in a few cases. Iridectomy and paracentesis of the aqueous chamber have also been recommended, with the object of rapidly reducing the intra-ocular tension.

Detachment of the retina.—Cases in which, either as the result of accident or of disease, the retina becomes detached from the choroid are of pretty frequent occurrence. The separation takes place between the hexagonal pigment layer and the layer of rods and cones, the former remaining attached to the choroid.

Detachment of the retina may be primary, that is to say, unaccompanied by any apparent inflammation, or secondary to affections such as cyclitis, which gradually lead to shrinking of the eye. Tumours springing from the choroid, too, give rise to detachment. In traumatic cases the separation may take place at once, or not until some time has elapsed. Idiopathic detachment of the retina comes on either suddenly or gradually; the first is more common.

The objective appearances met with are usually sufficiently characteristic to render the diagnosis with the aid of the ophthalmoscope easy. Occasionally, owing to transparency of the detached portion, or to this circumstance combined with shallowness and small extent of the detachment, the nature of the disease can only be made out with certainty by very careful examination. Often, too, a difficulty in the ophthalmoscopic diagnosis may arise from the presence of opacities in the lens or vitreous. The diagnosis is made by observing that some portion

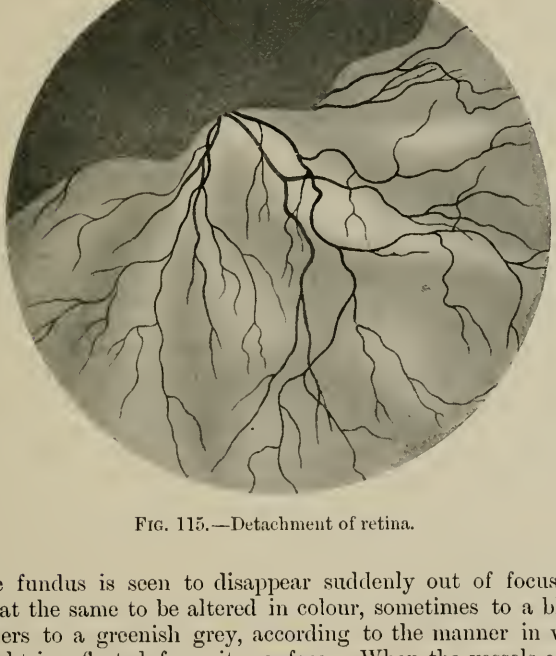


FIG. 115.—Detachment of retina.

of the fundus is seen to disappear suddenly out of focus, and often at the same to be altered in colour, sometimes to a bluish, at others to a greenish grey, according to the manner in which the light is reflected from its surface. When the vessels on the surface of this detached portion are focussed for, they appear darker by direct examination, and often smaller than normal.

When the retina remains clear, owing to the absence of any turbidity of the liquid behind it, no indication may be afforded by alteration of colour. The diagnosis will then depend upon one's finding an area which, in order to be distinctly seen,

requires an alteration in the focus. At the same time the vessels over this more hypermetropic area are blacker than in the immediate neighbourhood where the retina is in position. A parallactic movement of the vessels over the red fundus can often be made out too, more especially if a choroidal vessel can be seen behind the detachment.

At some portion of the detached retina there may be often seen a rent or rupture in it. This varies very much in size and has a very characteristic appearance, allowing the choroid to be seen with perfect distinctness through the opening. The margins of the rent may sometimes be seen turned in towards the vitreous.

In some cases, especially where the detachment has been hæmorrhagic, there may be seen irregularly disposed straw-coloured striæ or star-shaped opacities in the retina. These might be taken for scars, did they not frequently appear to interlace and lie behind perfectly intact vessels. They are in all probability fibrinous deposits at the back of the membrane.

In almost all cases where the detachment has existed for some time, and is not produced by tumour, the intra-ocular tension is found to be diminished.

The *subjective symptoms* vary according to the portion of the retina detached, the state of vision in the other eye, and the rapidity with which the detachment is developed. They are—defective central and peripheral vision, metamorphopsia, and night blindness. Often for a longer or shorter period, before any actual displacement has taken place, the patient complains of muscæ or black spots of different shapes and sizes floating in front of his eyes, and of subjective light sensations, flashes, and rays of light, coloured as well as uncoloured. When the detachment does occur, he is often conscious of a cloud coming in front of his field of vision. This is more likely to be observed in cases which come on suddenly and in which the vision of the other eye is lost. It is almost always noticed where the detachment is caused by tumour, as in such cases the central vision is, as a rule, relatively much better than in those in which the disease is idiopathic. At the same time the outlines of objects appear distorted. The apparent irregularity, too, which they present is apt to be inconstant, and to change much like the images reflected from the wavy surface of disturbed water. The distorted objects often appear to be bordered by colour.

There is usually more or less night blindness produced, both the light minimum and light difference being greatly reduced. There is often a remarkable tendency to confuse between blue and green.

In cases of detached retina, where the condition has lasted for some time, there is usually a marked contraction in the field of vision corresponding to the portion of retina detached. As the recently detached retina retains its function to some extent, the restriction of the field in fresh cases may often escape observation unless the examination is made in subdued light. The boundaries for peripheral colour vision are narrower than the line separating the undetached from the detached portion of the retina, that is to say, the field of vision is more restricted for colours than for white light. The defect in the field of vision has most frequently a more or less indefinite, ill-defined, and irregular boundary. If the field be at first restricted below, which is frequently the case, an extension upwards of the restriction is not unlikely to follow, corresponding to the tendency to gravitation of the subretinal liquid. In this extension, either or both sides of the field in the neighbourhood of the point of fixation may be involved, even the fixation point itself.

In almost all cases of simple detachment of the retina the central visual acuity is more or less diminished. This is often due, no doubt, to an œdematous condition at the macula. When the detachment is caused by tumour, the defect in the field is usually much more sharply defined, whilst the central vision may remain unaffected. This point may be of some diagnostic importance in a doubtful case.

When detachment of the retina occurs idiopathically, it is frequently found in both eyes. Only occasionally, however, does the detachment occur simultaneously, or nearly so, in the two eyes. Generally a considerable time, often many years, elapses before the second is affected. The occurrence of subjective light and colour sensations, and a notable increase in the number of muscæ, is always a suspicious circumstance.

Detachment of the retina is more frequent in old than in young individuals, the number of cases increasing with each decade, up to sixty at all events. It occurs in eyes presenting all the different states of refraction. In rather more than sixty per cent. there is myopia.

The retina may be detached at any part, but in a large proportion of cases some part of the upper half is detached.

Cases which have existed for some time are very often complicated with cataract, and the opaque lens not infrequently undergoes subsequent calcareous degeneration. Opacities in the vitreous are sometimes met with too, and this is almost always the case where the detachment has been caused by hæmorrhage,

either spontaneous or following injury to the eye. In these cases the opacities are often membranous.

The *prognosis* in detachment of the retina is always bad. Most cases go on to complete blindness, but, as a rule, in idiopathic cases the eye retains its shape and does not give trouble. Sometimes inflammatory changes make their appearance, and end in shrinking of the globe; at other times the subjective sensations give rise to much discomfort. In a very few cases im-

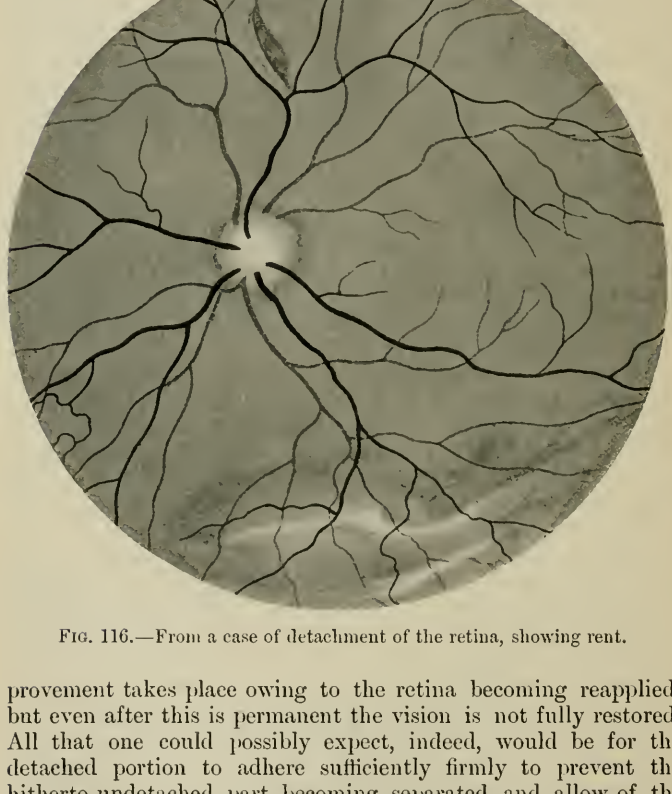


FIG. 116.—From a case of detachment of the retina, showing rent.

provement takes place owing to the retina becoming reapplied, but even after this is permanent the vision is not fully restored. All that one could possibly expect, indeed, would be for the detached portion to adhere sufficiently firmly to prevent the hitherto undetached part becoming separated, and allow of the improvement taking place in it which might be possible from the disappearance of any œdema. The prognosis is decidedly

more favourable in the case of young individuals. After sixty it is practically hopeless.

The *treatment* of detached retina has hitherto been very unsatisfactory. The fact that in some cases the retina does become temporarily or permanently reapplied if the detachment is recent, suggests the advisability of keeping the patient for some weeks lying on his back. It is customary to combine this with pilocarpine injections, or with other means of promoting absorption. Removal of the subretinal liquid by puncture through the sclera has also often been tried, but without any marked permanent success. A constant drainage of the subretinal space by means of a piece of gold wire left sticking through the sclera was for some time tried by Wecker, also unsucessfully. Schöler claims to have obtained good results by injecting a drop or two of tincture of iodine into the vitreous. Those who have followed him in this treatment have not been able to confirm his statements with regard to it. So far as the method has as yet been developed, it appears to be not only uncertain but even dangerous.

Detachment of the retina is, nevertheless, one of the few diseases of the fundus which we may not unreasonably hope some day to be able to check in some measure or prevent by active treatment. I have obtained the best results by repeated punctures made with a Graefe's knife pushed through from one side of the eye to the other in the region of the detachment. This is, I consider, always worth trying in young people. It is useless in complete detachment and in old people.

Opaque nerve fibres in the retina.—As they pass through the lamina cribrosa, the fibres of the optic nerve become divested of their myeline sheath. This accounts both for the comparatively small diameter of the papilla, and for the transparency of the fibres as they stretch over and form part of the retina.

In some cases, and in all probability as a congenital anomaly, because the myeline sheath is developed around the fibres of the optic nerve before birth, some of the fibres in the retina are rendered intransparent by being provided with a myeline covering. The appearance which this abnormality presents is very characteristic. It is seen as a brilliantly white patch, mostly extending from the upper or lower edge of the disc, sometimes from both at the same time. This patch almost invariably comes up to the margin of the disc, so as to appear quite continuous with it, while at its peripheral end it is less strongly defined, presenting a striated appearance owing to the sheaths of the fibres ending at different distances from their origin.

The patch is rarely as big as the disc itself; when bigger, it curves round over the macula. Occasionally a detached portion, at some distance from the papilla, has been seen, in which case the nerves after having lost their sheaths have again regained them. The vessels are almost always here and there hidden by the opaque fibres. Whether this is or is not the case depends partly on the depth and partly on the degree of opacity of the sheathed fibres.

There is little difficulty in diagnosing patches due to opaque

Fig. 117.—Opaque nerve fibres.—After Frost.

nerve fibres from inflammatory exudations in the retina. The latter are usually of a less dense white; they do not present the same striated appearance at their peripheral ends, do not come into such immediate contact with the margins of the disc, and are besides associated with hyperæmia, and often hæmorrhages, at other parts. I have seen the two conditions present at the same time without rendering the diagnosis difficult.

Opaque nerve fibres may occur in one or both eyes—more frequently, I think, only in one. They do not give rise to any defect of vision, further than as a rule some corresponding

degree of extension in the size of the blind spot. They are met with as the normal condition in some of the lower animals. In man they are uncommon, though by no means very rare.

Retinal changes produced by strong light.—Very persistent after-images may be produced by looking at the sun or a strong electric light. If the exposure has not been too prolonged, the defect of sight thus caused may be recovered from. A prolonged exposure gives rise to a coagulation at the macula, with the appearance of a small irregular patch in that region, and the production of a persistent central scotoma. Less strong sources of light also give rise to macular changes. I have seen such produced by constant use of the microscope. The changes in these cases appear to be more of the nature of small hæmorrhages at the macula. Sometimes they are apparently, in the less severe cases, mere temporary alterations in the arrangement of the pigment at the fovea. They may give rise to considerable central amblyopia with metamorphopsia, but the vision is usually slowly regained.

Diseases of the Optic Nerve.

Optic neuritis.—Inflammation of the optic nerve occurs either alone, when it is often called *papillitis*, or along with more or less inflammation of the surrounding retina—*neuro-retinitis.*

Papillitis is most frequently connected with some pathological change within the cranium; but such changes often lead to neuro-retinitis as well. It is characterised by more or less intense passive hyperæmia and swelling. The veins are engorged sometimes to an excessive degree, while the arteries, on the other hand, are normal in calibre or narrowed. The colour of the whole papilla is heightened, and the swelling causes it to become prominent, so that its surface is on a different level from that of the retina, while its margins, instead of being sharply defined, are more or less obliterated. The swollen nerve tissue also gives rise here and there to the disappearance of the vessels in the papilla, and these may be seen to dip abruptly at its margins as they continue their course in the retina. This obliteration of the margin of the disc is usually first noticed at its upper and lower edge, sometimes only to the nasal side. Often a very distinct striation can be made out on the swollen papilla as the bundles of swollen fibres are brought more prominently into view. There is at the same time more or less marked loss of transparency of the nerve tissue, and an increase,

often considerable, in the size of the disc. The degree of prominence of the swollen papilla can be appreciated by observing the difference in the strength of the glass, which is necessary to focus accurately the surface of the disc and the surrounding retina, and allowing roughly one millimetre for every three dioptres. The extent of parallactic movement gives a very good idea of the intensity of the swelling. The amount of swelling met with is very variable, and the time taken for the development of these changes very different.

Fig. 118.—Early stage of optic neuritis.

A considerable degree of papillitis may exist without interfering to any appreciable extent with the functions of the eye. The central and peripheral vision for both form and colour may be perfect. Sometimes the absence of any subjective symptoms lasts for months, but as a rule it is not long before the visual acuity becomes more or less reduced, and the sight may indeed be altogether lost. When such loss of vision occurs pretty suddenly, it should always arouse the suspicion of there being some other cause for it besides the swelling in the papilla. The gradual loss of vision is no doubt due to

compression of the nerve fibres in the papilla, by the gradual changes which the inflammatory exudation undergoes. An absence of visual disturbance at first affords no guarantee that such will not afterwards come on. When the central vision is affected, there is almost always at the same time a more or less concentric limitation of the field of vision, with greater or less loss of colour vision. Sometimes the restriction of the field is more irregular, affecting often the nasal half of the field more markedly than the temporal. The blind spot may be found to

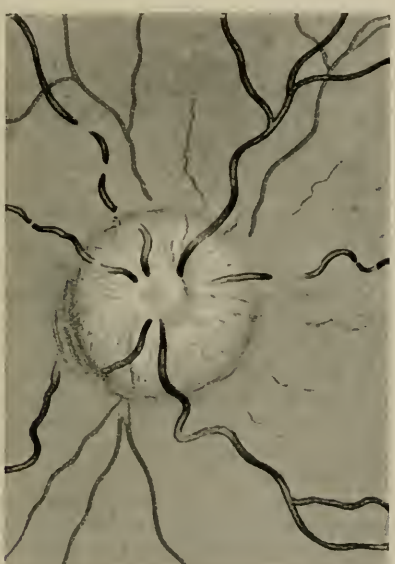


FIG. 119.—Later stage of optic neuritis.

be increased in size, especially if the test object be small and not very bright. The light-difference sense is diminished, but there is no night blindness.

Encephalopathic papillitis is practically always bilateral.

The condition of swelling of the papilla in which an accumulation of liquid in the sheath is supposed to be present, is often called *choked disc*. There are of course great differences in the degree of inflammation in different cases, but these differences are not due to essential differences in the etiology.

Not all pathological processes in the brain give rise to optic

neuritis. It occurs most frequently with tumours; indeed, so frequent is this association, that its recognition must be looked upon as a factor of primary importance in the diagnosis of cerebral tumour. Next in point of frequency comes neuritis along with meningitis. Some cases of hydrocephalus are associated with optic neuritis. More frequently a simple atrophy of the nerves is found in this connection. It is seen too, occasionally, in connection with purulent inflammation of the middle ear, when the inflammation has spread to the brain. Papillitis is rare altogether in cases of abscess of the brain. It is not met with in cerebral apoplexies, or in softening due to thrombosis.

There appears to be no invariable connection between the acuteness of the cerebral and ocular symptoms. A chronic neuritis probably signifies chronicity of the affection in the brain; while, on the other hand, an acute neuritis may be set up by chronic as well as acute disease.

After existing for a longer or shorter time, the neuritic process as a rule passes on to atrophy of the nerve, with more or less complete destruction of sight. Most frequently the blindness thus produced is eventually complete, and this may occur long before the brain disease leads to the death of the patient. At other times, after having progressed to a certain extent, the process remains stationary, and some degree of sight is left. This is more often the case in children than in adults, and mostly when the neuritis is originally connected with meningitis, in which cases it is generally less severe than when set up by tumour.

Some cases of neuritis get well without undergoing any, or only very slight traces of, atrophy. Mostly such cases have retained good vision throughout the period of inflammation, and only in such have I seen this practically complete recovery; but it appears undoubted that the vision, though defective at the time of the neuritis, may be restored without being permanently damaged by any subsequent atrophic process.

Tumours in the orbit, and inflammatory processes which have either begun in the orbit or spread into it from surrounding parts, may give rise, along with proptosis, to optic neuritis. As a rule, the swelling in the nerve is not so intense as in cases connected with tumours in the brain, and often a considerable acuity of vision may be retained, notwithstanding a high degree of protrusion. Deformities of the skull, owing probably to pressure on the nerve at the optic foramen, may be the cause of neuritis.

A number of cases of neuritis are altogether unconnected with disease either in the cranium or orbit. The etiology in such cases is often not very easily made out. They may occur after severe illnesses, without there being any definite connection between the particular disease and the neuritis. Other nerves may be affected at the same time; it is found, for instance, as one of the symptoms of more generalised neuritis. Syphilis, exposure to cold when there is more or less of a rheumatic disposition, and menstrual disturbances (particularly amenorrhœa and sudden suppression) all appear to be of undoubted causal influence. In all such cases, and especially in the more acute forms, the prognosis is on the whole much better than where the neuritis is merely a secondary manifestation. Even in cases where almost total blindness has been produced by the inflammation, a complete, or nearly complete, recovery may take place. Often a high degree of amblyopia, with or without restriction of the field of vision, is left.

An interesting and peculiar clinical type of optic neuritis is one which comes on generally shortly after puberty, almost exclusively in young men, and without there being any apparent immediate cause, other than a more or less markedly neurotic temperament. In such cases there is usually distinct evidence of heredity, several members of a family being affected. It always occurs in both eyes, causing, generally pretty suddenly, considerable blindness, first of the one eye and then of the other. The central vision is sometimes so much destroyed as to give rise to an almost absolute central scotoma, from which the patient does not as a rule recover. The objective symptoms are much like other cases of neuritis—they are rarely very pronounced, but there is usually well-marked perivasculitis.

The pathology of these cases is probably very closely allied to a not by any means uncommon, yet not very sharply defined, group of cases, which are generally looked upon as of the nature of *retrobulbar neuritis*. The characteristics of this group are—comparatively slight changes in the papilla, and the presence of a more or less definite central scotoma. The changes in the papilla may be so slight as altogether to escape detection, or they may amount to merely some slight haziness of its margins, and perhaps a trace of perivascular inflammation. After some time the outer half of the disc may exhibit an abnormal degree of pallor, whilst at the same time the contrast between it and the nasal half may be increased by some degree of injection of the latter. At other times a more general pallor of the disc results.

The central scotoma has often very much the same form as that which characterises toxic amblyopia, but it may differ from it in an important manner both in shape and extent. Just as in these cases, it is usually negative,—that is to say, it does not give rise to the sensation of any dark spot. Often a faint cloudiness is complained of in a bright light, and on account of this patients frequently state that they see better in a subdued light. On examination, however, this does not prove to be the case. At other times a more or less dark, generally buff-coloured, mist is complained of. The colour defect, too, in the region of the scotoma is much the same as in the toxic amblyopia. The scotoma does not present, however, the same regularity of shape, and is not confined to the area stretching from the disc to the macula to that area which is supplied by the papillo-macular fibres, changes in which have been shown to exist in certain cases of toxic amblyopia.

A point of considerable importance is the frequent extension of the affected area considerably to the inner side of the point of fixation, a condition which is not met with in typical cases of toxic amblyopia. At the same time in many cases there is some concentric limitation of the field of vision. Both eyes may be affected, but much more frequently only one. Where the disease is bilateral, it rarely gives rise to the same degree of amblyopia in the two eyes. It is about equally common in men and women.

Diagnosis.—The disease with which it is most likely to be confounded is the much more common toxic amblyopia. This mistake is not likely to be made except in bilateral cases. Even in one-sided cases the loss of sight of the other eye from some different cause may lead to this difficulty. The points to be attended to in the differential diagnosis are mainly—the irregular shape of the scotoma, more particularly its marked extension when large to the nasal side of the point of fixation; and the peripheral restriction of the field of vision. In some cases there is more or less pain complained of on moving the eye, or produced by pressing the eye back into the orbit. Generally, too, the pain is most marked when the eye is moved in some particular direction.

The *prognosis* is much less favourable than in toxic amblyopia. Some cases go on to complete blindness, others are left with an absolute central scotoma and the ophthalmoscopic appearances of optic atrophy. A certain proportion—not quite half probably, and these the more acute and less severe cases—recover in a few weeks from the onset of the disease. There can be no doubt

that the symptoms are produced by a superficial inflammation of the nerve in the orbit.

In the *treatment* of optic neuritis the cause has in the first place to be taken into consideration. Some cases depending on intra-cranial tumour have been relieved by the removal of the tumour. As far as any possible effect of such treatment on the vision goes, it has of course to be undertaken before the inflammatory changes in the nerve have proceeded too far. Removal of the liquid from the sheath of the optic nerve was recommended by Wecker as far back as 1872, but has not received much attention.

Atrophy of the optic nerve.—Atrophy of the optic nerve may be *primary*,—that is to say, it may originate in the nerve itself, or it may be *secondary* to changes which have occurred either in the retina or in the central nervous system. The atrophy may, as we have seen, follow inflammation; it is then usually termed post-neuritic or post-papillitic atrophy; or it may be simply due to degenerative processes of different natures.

The ophthalmoscopic appearances are—pallor of the disc, often accompanied by some degree of excavation, and by narrowing of the calibre of the vessels. The scleral ring is generally more than usually well marked, owing no doubt to some degree of shrivelling or contraction, which only rarely gives rise to any distinct diminution in the size of the disc. The loss of colour in the disc, which first becomes marked as a rule to its outer side, is due partly to diminution of vascularity, and partly to disappearance of the nerve tissue, leaving only the white connective tissue, often increased in amount, behind. When this is the case, there is produced a shallow excavation, known as an *atrophic excavation*.

From the mere colour of the disc, without taking into consideration the size of the vessels and the existence of an excavation of this nature, it would be rash to conclude that there was atrophy, unless perhaps the light reflected from its surface had not only lost all tinge of yellow or pink, but also become bluish or greenish in hue. Considerable variations take place with respect to colour within physiological limits; a very anæmic condition of the disc may, too, although it may hardly be normal, exist without any, or any great, functional disturbance, and yet not be of the nature of atrophy. Great pallor, with loss of transparency of the disc, due to consolidation of some exuded matter, is found in cases in which a neuritis has been completely recovered from, and not followed by atrophy.

Even when the ophthalmoscopic appearances—pallor, excava

tion, and narrowing of the vessels—leave no doubt as to the existence of an atrophic process, it is impossible to say, with any degree of certainty, from a consideration of the picture thus presented to one, whether the process is a progressive one or not. When the atrophy is evidently post-neuritic, the chances of its becoming arrested at some stage short of complete blindness are generally greater than when it is the result of a more distinctively degenerative change. Post-neuritic atrophy is characterised by more or less indistinctness and want of definition of the margins of the disc, and in many cases by white patches on its surface. These patches stretch between, and sometimes cover, the bifurcations of the vessels, and extend along the main trunks as white lines. This condition of perivasculitis is often not confined to the disc alone, but extends for a greater or less distance along the vessels into the retina.

A good deal more light is often thrown on the question as to whether in any given case the atrophy is likely to be progressive or not—that is to say, is likely to progress to such an extent as eventually to destroy vision—by a careful examination of the subjective symptoms caused by the degeneration. These symptoms are—defects in the central vision, restrictions of the field of vision, and defects in the colour and light sense.

In all cases where the atrophic process in the nerve is primary, or due to some interruption at any part of its course, and not secondary to alterations in the choroid and retina, there is no interference with the light-minimum sense. On the other hand, the power of distinguishing between intensities of illumination is less acute than normal, often indeed very markedly so. Such a defect of the light sense is characteristic of any affection originating in, or mainly implicating, the nerve tissue itself.

The most common form of restriction of the field in atrophy is the concentric. Often, however, the defect in one direction may be much greater than in others; and when this is the case, it not infrequently happens that a good deal of symmetry in this respect is to be found in both eyes, even although the atrophy may be much more advanced in the one than in the other.

In all cases of progressive atrophy, the restriction which is taking place can probably be most easily demonstrated for colours. This is mainly because, if the examination is made in ordinary daylight, the corresponding failure of the sense of form may, if slight, more readily escape detection. If the test is made by Bjerrum's method with very small objects (see Chap. II.), the restriction for form can always be demonstrated.

There seems every reason to suppose that the colour defect in progressive atrophy is accounted for by the relatively greater perfection of conductibility which is necessary for the transmission of stimuli destined to give rise to colour sensation. Colour tests are therefore more delicate tests for the detection of diminished conduction than the commonly applied tests for the sense of form.

Restriction of the field vision, when more or less concentric, and especially when the colour defect is pronounced, is always very suggestive of progression.

Usually the defect of central vision keeps pace with the gradual narrowing of the field, so that when there is much restriction there is generally at the same time considerable amblyopia. In some cases the central vision remains relatively very good, but it is seldom that this can be looked upon as a good sign,—in fact, the prognosis mainly depends on the state of the peripheral vision. In the same way, if during the progress of a case it is found that the vision gets no worse for some time, this is only a favourable sign if at the same time the state of the field remains stationary as well. Some cases, particularly when the atrophy results from neuritis, progress to a certain extent, leading to both restriction of the field of vision and defective central vision, and then become arrested.

In all cases where there is merely a central scotoma, without any narrowing of the field, the prognosis is good,—that is to say, the scotoma may become absolute, but vision is not likely eventually to be lost altogether, notwithstanding the objective appearances.

Neither from the ophthalmoscopic changes nor from any peculiarities in the symptoms does it seem possible to diagnose the cause of the atrophy without taking into consideration other circumstances. An atrophy due to spinal disease is often, though not always, complicated at the time of examination by ataxic or other spinal symptoms, or by abnormalities in connection with the pupil, loss of knee-jerk, etc. ; one which is connected with cerebral disease is frequently followed, though rarely preceded, by mental derangements. Some of the primary degenerative changes in the optic nerve, which are always bilateral, are local expressions of the same conditions which give rise to tabes, and as such may precede the other symptoms. They are not extensions, but independent degenerations. Sometimes the degeneration begins at the central terminations, at other times at more peripheral parts of the optic nerves. Apart from what has been shown to exist anatomically, Nettleship considers that

the absence of pre-atrophic amblyopia affords strong clinical evidence of the peripheral and entirely isolated nature of the degeneration, which in cases of tabes leads to progressive atrophy. In other cases the atrophy appears to be altogether unconnected with any similar process elsewhere; it is at all events not, even after the lapse of many years, followed by any changes in the central nervous system. Yet it may perhaps be looked upon as not improbably a manifestation of the same disease.

Unilateral atrophies are generally the result of some process originating either in the retina or the orbit, but they may be caused by compression within the cranium either of the nerve or of the vessels supplying it. The latter cause may be suspected when there is marked evidence of arterio-sclerosis elsewhere.

Of the bilateral forms of cerebro-spinal origin some idea of the process giving rise to them may be gathered from the ophthalmoscopic appearances; thus the opaque-looking atrophic degeneration, with narrowing of the vessels, points to changes mainly involving the connective tissue and destroying the nerve elements. It may be taken as a general rule—to which, however, there are exceptions—that degenerative processes beginning at the base of the brain, while they lead to pallor, are not associated with diminution in the vessels unless the atrophic process has at any time been complicated by a papillitis. Processes which begin in the papilla itself, and involve the connective tissue, as they affect that portion of the nerve in which the central vessels are situated, do cause constriction of these vessels, and thus give rise to a different ophthalmoscopic picture.

A large proportion of cases of bilateral atrophy are certainly due to the same causes which give rise to degenerative changes in the sensory tracts of the spinal cord and brain.

The ophthalmoscopic changes characteristic of atrophy are not met with where it is due to disease at one visual centre, and the defect in vision produced is of the hemianopic type. Anything like extensive degeneration in these cases only spreads downwards as far as the external geniculate body. It seems likely that when, as happens in a certain proportion,—probably quite ten per cent. of cases of general paralysis,—there is optic atrophy, there is at the same time some spinal degeneration. Atrophy in disseminated sclerosis is most frequently accompanied by other paralysis of cranial nerves, *e.g.*, of the sixth, seventh, etc.

The eye symptoms in connection with spinal lesions are often of importance from a diagnostic point of view, as showing the

eventually slow degenerative nature of the disease, even when, as sometimes happens at the time of first examination, the symptoms from the side of the cord are acute. Spinal as well as primary optic atrophy is a great deal more common in men than in women.

Altogether, optic atrophy accounts for fully one-fourth of all cases of blindness.

CHAPTER IX.

DISEASES OF THE IRIS AND CILIARY BODY.

The Iris.

Notwithstanding that a most intimate anatomical connection exists between the different parts of the uveal tract (the iris, ciliary body, and choroid), it is more common to find inflammation localised either throughout its whole course or, for some time at all events, to one particular portion of that tract, than to meet with a general uveitis.

This is greatly owing no doubt to the differences which exist in the source from which the blood supply for the various parts is immediately drawn. In this respect the iris and ciliary body are the most intimately connected, both being supplied by the anterior and posterior long ciliary arteries. The choroid, whose main function is to convey nutrition to the retina, is not only supplied from a different source, namely, the short posterior ciliary arteries, but is traversed by a network of vessels which are relatively richer in blood.

The choroid, with its peculiar vascular supply, is mostly subject to inflammation occurring in variously disposed and localised patches. The anterior portion of the uveal tract shows, on the other hand, a greater tendency to diffuse inflammation. The iris and ciliary body are frequently inflamed at the same time. This is almost invariably the case when the inflammation is first set up in the ciliary body. When originating in the iris, it is not uncommonly confined to it.

Inflammation of the iris—*iritis*—may, from a clinical point of view, be looked upon as occurring under three forms—(1) plastic, (2) serous, (3) purulent.

It may be *primary*, or *secondary* to some general affection or dyscrasia. The most important forms, considered etiologically, and pretty much in the order of frequency in which they are usually met with, are—(1) rheumatic, (2) syphilitic, (3)

traumatic, (4) sympathetic, (5) gonorrhœal, and (6) tuberculous, iritis.

Hyperæmia of the iris.—Congestion of the vessels, which gives rise to some discoloration of the iris as a whole, and often at the same time to more or less contraction of the pupil (miosis), is a frequent accompaniment of irritation or inflammation elsewhere in the eye. It is met with, for instance, very frequently where foreign bodies, lodged in the cornea for some time, have produced a local irritation. It is also seen along with different forms of keratitis, with scleritis and inflammation of the deeper coats of the eye, and is, of course, also one of the first changes which take place when the iris itself becomes either primarily or secondarily inflamed. The hyperæmia gives a greenish coloration to blue and a dirty reddish appearance to dark irides.

When miosis—what has been by Nettleship very appropriately called *congestive miosis*—exists along with the hyperæmia, the pupil should be kept dilated with atropine.

Iritis. — Inflammation of the iris, from whatever cause, presents certain well-marked symptoms. When acute, there is always considerable *pain* referred not only to the eye, but also, and in most cases indeed principally, to the surrounding parts—forehead, sides of the nose, etc. The pain is usually much less severe in the daytime—exacerbations coming on at night and during the early hours of the morning. In the serous and chronic forms of iritis there is generally little or no pain.

The pain of iritis is spontaneous, and accompanied by photophobia and lachrymation. It is often increased by light falling into the eye, and also by attempts at reading or using the eyes for any purpose requiring active accommodative effort—in short, by anything which produces, or tends to produce, changes in the shape of the pupil. Temperature, too, is not without influence. As a rule, the pain is increased by cold, whereas warmth has often a markedly soothing effect. There is always more or less sensitiveness to touch.

The course of an acute iritis is pretty definitely indicated by the amount of pain. As the inflammation subsides, the pain becomes less severe, while greater pain at any time almost invariably co-exists with exacerbations of the inflammation. As a rule, too, the more acute the pain, the more severe is the inflammation.

Another constant sign of iritis is a *circumcorneal injection*—that is, an injection of the fine network of deeper vessels which immediately surround the cornea. These vessels, the episcleral or

subconjunctival vessels, are branches of the anterior ciliary arteries and veins. They form a network around the cornea, a quarter of an inch or so in breadth, the finest meshes of which lie nearest to the cornea. According to the severity of the iritis, there are differences in the breadth of the ring of injection. Less severe cases are accompanied by injection of only a comparatively narrow band, *i.e.*, only the vessels immediately surrounding the cornea are distinctly visible as a pinkish zone. With increased intensity in the iritis this zone widens out, and in very severe cases may be associated with hyperæmia of the more superficial vessels of the ocular conjunctiva as well, or even in the most acute plastic forms, and in purulent iritis, with chemosis. When there is no irritation or focus of inflammation in the cornea, a circumcorneal injection is indicative of a deep-seated inflammation, so that its existence in such cases should at once direct attention to the iris.

The breadth and intensity of the circumcorneal injection is, just as the amount of pain suffered, a good measure of the severity of the iritis. With ordinary care it is impossible to mistake it for conjunctival hyperæmia, but the possibility of the deep and superficial injections co-existing should be borne in mind, as in that case the differential diagnosis presents rather more difficulty. It is seldom that any marked degree of swelling or redness of the eyelids occurs in iritis, except in the purulent form; at most, there is usually only a little redness, confined to the margin of the upper lid.

A third sign is *hyperæmia of the iris*. The hyperæmia is often most distinctly visible in the region of the sphincter pupillæ, *i.e.*, in the zone almost immediately surrounding the pupil, where some of the branches of the arteries in the iris form a ring. Sometimes, commonly enough in cases of traumatic iritis for instance, the engorged vessels give way, and lead to an effusion of blood into the anterior chamber (hyphæma). The inflamed iris is not only altered in colour, owing to hyperæmia, but the glistening appearance which its surface presents in health is lost, while the markings on its surface, in so far at least as these can be seen with the naked eye, are more or less effaced. This *muddiness of the iris* is the result of exudation into the surrounding aqueous, as well as into its own tissues, and is therefore more or less complete according to the nature and amount of the exuded material. The parenchymatous exudation leads to thickening of the iris. The thickening is usually not very great, and tolerably uniform throughout, although perhaps most marked near the pupil. Sometimes, however, it

forms prominent masses projecting more or less into the anterior chamber, and single or multiple. Such masses are mostly either tuberculous or syphilitic in their nature.

The exudation, which does not infiltrate the tissues of the iris itself, passes into the posterior and anterior aqueous chambers, and leads to adhesions, more or less complete and firm, between the posterior surface of the pupillary margin and the anterior capsule of the lens. These adhesions, or *posterior synechiæ* as they are called, form one of the chief and most serious complications of iritis. They interfere with the mobility of the pupil, and render the result of subsequent attacks much more serious than they might be, as the pupil may then be more or less occluded by exudation passing from one side to the other. The synechiæ which form in an ordinary case of iritis, where the inflammation has not been prolonged and severe, or the exudation excessively plastic, are generally punctiform. That is to say, there is not, as a rule, from one attack (and more especially if proper treatment has been adopted at an early stage), a continuous attachment of the pupillary border to the lens capsule; only isolated attachments here and there. These, too, are often most numerous at the lower part of the pupil, as the exudation which gives rise to them gravitates to the most dependent portion of the area over which the back of the iris is in contact with the lens capsule, and this is most often the lower part of the pupil. The synechiæ are apt to form during the night, partly on account of the exudations which then take place, and partly, no doubt, owing to the iris then being more constantly at rest than during the day.

The tacking down of the iris is not noticeable, as a rule, unless an attempt is made to dilate the pupil, when, instead of remaining round, it assumes an irregular shape, due to irregularity in the dilatation, which results from adhesions in some situations and not in others. Some days elapse before the synechiæ become so firm as to resist any ordinary effort, such as may be made by a mydriatic, that is, a substance which has the power of causing dilatation of the pupil. Fresh attachments yield in this way, usually leaving behind them some pigment from the back of the iris, so that it is not an uncommon thing to see, in an eye in which there has previously been iritis, a number of pigment spots on the surface of the capsule, indicating the positions of the former attachments.

In severe cases of iritis, or in cases where proper treatment has been neglected at the first, and in which there have been more or less frequent recurrences of inflammation at different

periods, a complete agglutination between the iris and capsule takes place. Sometimes this may be so complete as to abolish altogether the space through which the aqueous humour which is exuded from the walls of the posterior chamber finds its way into the anterior chamber. This is called *exclusion* of the pupil. In the very worst cases, always complicated with cyclitis, the exudation is extremely plastic and copious, and leads not only to agglutination of the pupillary margin, but to an attachment of the back of the iris to the lens capsule, and to a practical obliteration of the posterior aqueous chamber.

The exudation which passes into the anterior chamber causes in many cases a mere cloudiness and discoloration of the aqueous

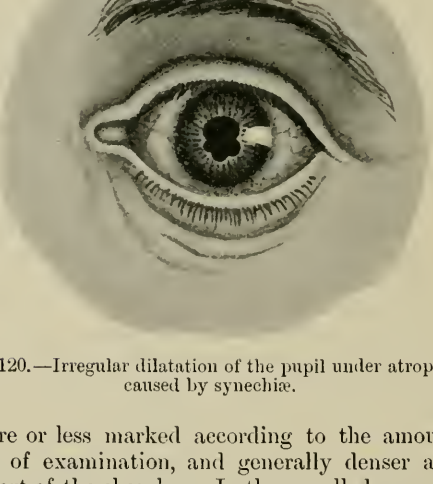


FIG. 120.—Irregular dilatation of the pupil under atropine, caused by synechiæ.

humour, more or less marked according to the amount existing at the time of examination, and generally denser at the most dependent part of the chamber. In the so-called serous iritis little deposits of lymph take place on the walls of the anterior chamber.

In some cases of plastic iritis a spongy-looking fibrinous mass may be seen lying in the anterior chamber.

In purulent iritis the pus secreted from the inflamed tissues collects in the anterior chamber, where it falls to the most dependent part as *hypopyon*.

The hyperæmia of the iris, as well as the synechiæ, give rise to another sign of iritis, namely, a *sluggishness in the movements of the pupil*.

In uncomplicated iritis the vision suffers at first only in so far as can be accounted for by the amount of obscuration in the pupil and aqueous humour in front of it. There is therefore frequently no great *diminution of visual acuity*. In cases where there is, the pupil is to a great extent occluded by lymph, or the iritis is complicated with choroiditis, or with cyclitis, along with effusion into the vitreous. Before referring any visual defect, found on examination, to the inflammatory changes in the eye, it is well to test whether vision is not improved with any glass. Owing to the inflammation, a previously latent degree of hypermetropia may become manifest. It occasionally happens, too, that the lens is somewhat pushed forward, so as to give rise to a slight degree of myopia.

Some *increase in intra-ocular tension* probably always takes place in iritis. When there is not a very copious exudation, it is often, however, impossible to detect the increase; in other cases, especially in serous iritis, it may be very marked indeed. At later stages of the disease, after the supervention of secondary changes, it is very common to find first an increase, and subsequently a diminution, of the tension within the eye.

Very great differences are met with in the *duration of an attack* of iritis, as many cases, even such as eventually lead to the very worst consequences, so far as the functions of the eye are concerned, run a chronic and more or less painless course from the beginning. In some more acute cases, again, relapses may take place, and thus the inflammation is protracted beyond its natural duration. Very much, indeed, depends on the treatment adopted from the first. Most acute cases, if properly treated, last from three to six weeks.

In some cases, where the iritis exists along with some other affection, as for instance some cases of gonorrhœal iritis, there is a tendency to the recurrence of the iritis every time that the symptoms with which it has previously been associated make their appearance.

There is an important class of case in which the recurrence takes place from time to time without there being any very marked association with other affections. Such cases have received the name of *recurrent iritis*. Sometimes the recurrence takes place at regular intervals, most frequently at or about the same season, year after year. More commonly there is no such regularity exhibited in the periods of recurrence.

When an annular adhesion has taken place, so that the pupil is completely blocked, further changes usually soon begin in the eye, owing to the liquid secreted from the ciliary processes not

being able to find its way forwards, and thus escape from the eye. The iris is then bulged forward, so that the anterior chamber is shallowed, except at its centre. The appearance presented by this condition is well called by French writers "iris bombé." The vision then no longer corresponds to the opacities in or in front of the pupil, but is diminished by changes in the vitreous or choroid, or more frequently by those which the accompanying increased intra-ocular tension gives rise to. Eventually complete blindness from detachment of the retina, or secondary glaucoma, is the result if operative interference has not been made in good time.

Iritis is most common during the first three decades of life, and perhaps least common in infancy or early childhood.

Fig. 121.—Iris bombé, with exudation on lens capsule.

Diagnosis.—The iris is not only relatively frequently inflamed, but serious harm is apt to result if an iritis is allowed to take its own course or receives improper treatment. For these reasons the diagnosis is a matter of great practical importance. In all cases in which the white of the eye is congested, the very first question to be considered is as to whether or not this indicates the presence of either an already established or a threatened attack of inflammation of the iris. A careful examination, especially of the distribution of the hyperæmic area, the transparency of the aqueous humour, and the lustre or glossiness of the surface of the iris, should seldom fail to lead to a correct diagnosis in the

first stages of an iritis. Later on, the irregularity in the shape of the pupil, or its immobility, and the greater or less defect of vision, render the diagnosis easy. It is, however, in the early stage that it is perhaps most important no mistake should be made. This stage, too, more frequently comes under the observation of the family physician than of the ophthalmic surgeon. He will have in many cases to distinguish between the symptoms of a superficial inflammation and a deep, such as iritis; and should he find the diagnosis difficult, it will generally be better for his patient not to run the risk of delay, but to at once adopt a treatment by which the evil effects of iritis may be kept off. A false alarm in this respect is preferable to a neglected opportunity.

The only other condition, besides superficial inflammation of

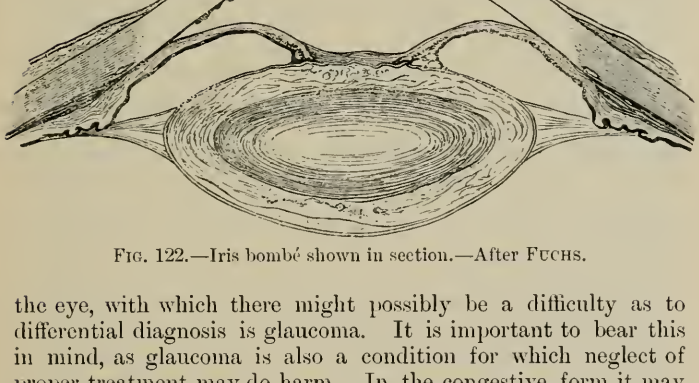


Fig. 122.—Iris bombé shown in section.—After Fuchs.

the eye, with which there might possibly be a difficulty as to differential diagnosis is glaucoma. It is important to bear this in mind, as glaucoma is also a condition for which neglect of proper treatment may do harm. In the congestive form it may present appearances not unlike those of iritis. The age of the patient, the previous history of "haloes" and obscurations, the condition of the field of vision, and, above all, the peculiar stippled and steamy appearance of the cornea, would point more or less definitely to glaucoma.

One way in which the congestion of the white of the eye which is indicative of deep-seated inflammation differs from that associated with conjunctivitis only, is in its distribution. In both cases there may be more or less redness of the whole of the white of the eye, but whereas in conjunctivitis the redness diminishes in intensity from the periphery to the cornea, it is just the

opposite with a deep congestion. More especially, then, when one sees a dense injection of fine vessels surrounding the cornea, must one's attention be directed towards the existence of deeper mischief. Of course, in any such case the cornea itself would be carefully inspected, and, in the absence of any abnormality there, the cause of the circumcorneal injection looked for in the deeper structures of the eye.

Hyperæmia of the iris itself causes, according to its degree and the original colour of the iris, more or less appreciable change in that colour. Light irides show slight changes in vascularity more readily than dark. Where there is any circumcorneal injection then in one eye only, a careful comparison of the two irides should be made, in a good light. Any difference that there may be in respect to their colour, and due to congestion, is always most apparent in the areas immediately surrounding the pupil. As soon as the engorged vessels of the iris begin to transude, the serous surface loses its beautiful gloss and becomes dulled. A difference in this respect also should therefore always be looked for, where there is any reason to suspect inflammation of the iris.

Pain is not always present in iritis, and therefore although it is, from the point of view of treatment, an important element to consider, it is of comparatively little value in diagnosis. Still, where with other appearances of iritis there were found to be localised spots of tenderness on pressure on the eye, and a history of severe nocturnal exacerbations of spontaneous pain, these symptoms would be useful in further helping to establish or confirm the diagnosis.

With proper care, then, there should usually be little difficulty in diagnosing iritis. The further diagnosis of the cause of the localised inflammation is often, however, by no means an easy matter. Fortunately the treatment is only to a certain extent influenced by the correct diagnosis of the cause.

The *treatment* of iritis should vary to some extent according to the cause of the inflammation, and may therefore be considered under the headings of *special* and *general* treatment. The special treatment, applicable to the different forms of iritis, is referred to in connection with the discussion of each form. The general treatment, applicable to all cases, may be divided into that to be adopted at the time of the inflammation, and that which is necessary in order to avert the consequences of the complications to which it gives rise. What should be aimed at, at the time of the inflammation, is to put the eye as far as possible at rest, to prevent the formation of synechiæ, and alleviate the pain.

An attempt is made to *get the pupil thoroughly dilated* with atropine, and this dilatation should be kept up as long as any circumcorneal injection lasts. Care should be taken in applying the atropine drops that they really get into the eye, and are not washed away by the copious flow of tears met with in most cases.

If a case of iritis be left to take its own course, or treated without the use of a mydriatic, it almost invariably happens that posterior synechiæ form. Sometimes, indeed, when there is much fibrinous exudation from the inflamed iris, some of it may become organised into a membrane stretching across and more or less completely occluding the pupil. The risk of this happening is all the greater, owing to the tendency that there always is for the pupil to be contracted when the iris is inflamed.

Synechiæ alone, though they do not cause any direct impairment of vision, are always an undesirable complication. They at least increase the risk that the eye runs from every subsequent attack of iritis. The possibility of recurrence, too, should always be kept in mind. The view that recurrence is favoured by the presence of synechiæ is, I think, hardly sufficiently probable to serve as a guide to treatment At all events, no attempt to detach such posterior synechiæ, when they are of sufficiently old standing to have become regularly organised, should be made. The only thing that may be justifiable is to perform an iridectomy.

If the case has first come under observation when the synechiæ have begun to form, continued use of atropine may lead to their rupture, and a good dilatation may be got even after several days. In most cases, at all events, the unattached portion of the pupil dilates, and further mischief is to a great extent obviated.

Whilst the supposed influence in causing recurrence which has been ascribed to synechiæ need not be considered, it does not follow that a more or less constant drag on these adhesions has never, under any circumstances, an irritative effect upon the iris. The conditions in this respect are undoubtedly quite different when we compare the cases where there exists at the time an inflammation of the iris with those in which the iritis has long since subsided. It is a very common error to suppose that because it is in general desirable to use atropine or some other mydriatic during the whole course of an attack of iritis, it is always right to do so. In many instances the discontinuance of atropine is followed by a very rapid improvement. The reason of this is that as the main call for a mydriatic is to produce dilatation and thus prevent synechiæ, the *raison d'être* of such treatment

no longer exists when, having been begun too late, the pupil cannot be properly dilated by it. A dragging to no purpose on the already firm synechiæ, with the iris inflamed, may do harm. It certainly tends to irritate and to keep up the inflammation. As, too, the continuance of the inflammation means often the exudation of more and more plastic matter, the consequences may be more serious than if the patient were left without any treatment at all. A practical guide in this respect may be formulated as follows:—If the free use of the mydriatic (applied, *i.e.*, three or four times in the twenty-four hours) for three or four days in any case of iritis, seen or recognised only some time after it has begun, fails to cause any satisfactory dilatation of the pupil, it should be discontinued.

Another practical point connected with the use of atropine in iritis, and one as to which the proper course to take is often a matter of no little difficulty, is the possibility of the treatment leading to increased intra-ocular tension. In elderly people especially, it is important always to be on the lookout for this complication. Should it arise, the first thing to be done is to stop the atropine. If the tension is then soon restored to normal, it may be resumed before the pupil has become quite small. It must then, however, be used with caution, and not so free a dilatation aimed at. The best thing to do is to diminish both the frequency of the applications and the strength of the mydriatic solution. A $\frac{1}{4}$ per cent. solution of atropine, used once every second day, should be tried; or homatropine solution of the same strength may be substituted for the atropine. Where the glaucomatous symptoms persist, or return with the use of even a weak mydriatic, a sclerotomy, done in the manner described at p. 384, is in some cases useful. The cases in which sclerotomy may be resorted to are the cases of serous irido-cyclitis; cases in which the inflammatory symptoms are less pronounced, and pain either not at all complained of, or, comparatively speaking, slight. In more violent plastic iritis, any operation at the time of the inflammation is contra-indicated. Mydriatics must be altogether given up, and surgical treatment deferred until after recovery. If anything then seems advisable, an iridectomy is generally to be preferred to sclerotomy.

In addition to keeping the pupil dilated, whenever this is possible, it is important, in all cases of iritis, to *keep the eyes shaded* from the light. This may either be done by darkening the room or by the use of dark glasses (neutral-tinted or "smoked" glass, not blue). If the patient is able to be up, the latter method of subduing the light is preferable. He can

then occupy the same rooms as, and enjoy the society of, other inmates of the house. Both eyes must be shaded. It is useless to cover the inflamed one with a handkerchief or bandage, as is often done, and leave the other one exposed to the untempered and constantly changing light of an ordinary room.

During an attack of iritis, any use of the eyes for reading or sewing, or work of any kind calling for accommodation, must be prohibited. If there be any difficulty in enforcing this, it is a good plan to drop an occasional drop of atropine into the good eye, which, by paralysing the ciliary muscle, makes reading difficult or impossible without convex glasses, unless there is a sufficiently high degree of myopia. Even in myopic patients, although the accommodative effort made is not nearly so great, it is better not to allow reading.

In many cases, and particularly those of a rheumatic origin, the pain which accompanies inflammation of the iris is often so great as to call for special treatment. The pain may be more or less relieved by both local applications and drugs taken internally. It is particularly aggravated by light and by cold. Where it is intense, therefore, it is best to keep the patient in semi-darkness and in bed in a room in which the temperature is kept equable, and protection made against draughts. Generally, the pain is most severe during the night, especially from midnight to four or five o'clock in the morning. Leeching (either with the natural or artificial leech) used to be a very common treatment for painful iritis. No doubt leeches applied to the temple have often a very marked effect in dispelling the pain. Their effect is, however, only temporary, and is rarely superior to less troublesome means of producing relief. They do not influence in any way the course of the inflammation. In my own practice I have long since given up leeching, and rely entirely upon the application of heat. Hot fomentations may be used for a quarter of an hour at a time, every two hours or oftener, at the times when the pain is most severe. After using the fomentations, the eye may be covered with a pad of cotton-wool, retained by a loose bandage. Cocaine alone or combined with adrenalin dropped into the eye immediately before fomenting sometimes helps, but it should only be used in cases where the pupil has dilated well under atropine. Of drugs, antipyrin or phenacetin in 10-gr. doses, and salicin, are the most generally useful. In many cases salicin has the effect of rapidly relieving the pain. It should be used from the beginning, being given in 7- or 8-gr. doses every hour for ten or twelve hours, or until toxic effects are manifested; then thrice daily in 10- or 15-gr. doses.

The treatment sometimes required for cases of old iritis is iridectomy. This operation is called for in two different classes of cases. In the first place, to improve vision where the pupil is small, and to a great extent occluded, though the condition has not led to serious nutritive changes; and in the second place, with the object, as well, of preventing the complete destruction of vision which either the existing condition or the danger of recurrence of the inflammation has threatened. Iridectomy, when performed for iritis, should be done at a time when all symptoms of inflammation have subsided, and the portion of iris excised should be large, so that in the event of a subsequent attack taking place, the coloboma, or artificial pupil, may be less likely to close up. At the same time, a large iridectomy gives the best chance for the re-establishment of the normal flow of aqueous from the site of its exudation to that by which it leaves the eye, the interruption in which process may have such serious consequences. Iridectomy is urgently called for, and often followed by the most brilliant results, where there is an "iris bombé" and increased intra-ocular tension. Even in cases where the tension is below normal, if there be not already blindness, iridectomy may prove of service. In recurrent iritis, too, an iridectomy, performed at a time when the inflammation has subsided, often prevents the recurrence or lessens the frequency and severity of subsequent attacks. Fortunately, when synechiæ are ruptured during the excision of a piece of iris in this operation, it is extremely rare to find that their attachment to the lens capsule is sufficiently firm to lead to any laceration of that membrane. Practically speaking, this never occurs. If it did, the risk of iridectomy causing cataract would be very much greater than it actually is, and the great benefits which are derived from surgical interference in cases of neglected iritis would be seriously curtailed.

Other operations which are performed for old iritis, such as attempts at separating the synechiæ, and sclerotomy, are either less safe or less efficient than iridectomy, and on that account not to be recommended. In the worst cases, where the iris has become friable or "rotten," and more or less atrophied from repeated inflammation, and where the attachments to the capsule are very extensive owing to the association with cyclitis, it is sometimes possible to improve vision and prevent further destruction taking place by removing the lens. An operation of this nature is most frequently called for in cases of severe sympathetic iritis.

When iritis is not set up by injury, the two most common causes are rheumatism and syphilis.

Rheumatic iritis.—This form of iritis occurs most frequently during the prime of life, between the ages of 20 and 50. There is often a distinct history of former rheumatic affections elsewhere, or there may be other parts affected with rheumatic inflammation at the same time. At other times there is no other rheumatic manifestation, and yet a great tendency shown to iritis from exposure to cold. Most frequently only one eye is affected, but both may be, either at the same time or within a short interval. The inflammation occurs with very varying degrees of severity, and the prognosis, even in the most severe cases, is favourable if proper treatment be adopted from the first, before extensive synechiæ have formed or cyclitis has become developed.

The *treatment* consists in avoiding changes of temperature or light and the use of the eyes, also in keeping up the dilatation of the pupil—in attention, in fact, to the general line of treatment for iritis. Besides this, great benefit is usually got from the use of salicin or salicylate of soda. Perhaps the best way of using salicin is for the patient to begin taking 7 to 8 grs. every hour, remaining in bed all the time, and afterwards to take from 10 to 15 grs. thrice daily for some time. In this way it is sometimes possible to cut short the attacks, and in almost all cases the pain is lessened. In obstinate recurrent cases it is well to avoid too much care in preventing draughts, etc., as the susceptibility of the patient may thereby be considerably increased. It is better to make some systematic attempts at a gradual hardening, and allow more and more exposure to the conditions which appear to bring about the attacks. At the same time, two or three visits to Wiesbaden often do good. The baths, not the waters, should be taken, and should not be begun until a few weeks at anyrate have elapsed since the last attack of inflammation. In the distinctly rheumatic, other baths, such as Harrogate, Bath, Droitwich, Nauheim, Wildbad, Acqui, etc., may be recommended.

Gonorrhœal iritis.—Closely allied to rheumatic iritis is the rare form which is associated with gonorrhœa. The inflammation is always severe. It always occurs in both eyes, though not always quite simultaneously, and with, it may be, different degrees of severity in the two eyes. Successive attacks of gonorrhœa are sometimes accompanied each time by iritis, and in other cases, although no fresh inoculation takes place, a return of the joint affections may be accompanied by a recurrence of the iritis as well.

The local *treatment* is the same as for other forms of iritis.

Iodide of potassium in large doses seems to be the best general treatment at first, followed, as the inflammation subsides, by quinine and iron.

Syphilitic iritis.—Iritis occurs as a secondary manifestation of acquired syphilis, and also in inherited syphilis. Iritis is for the most part a late secondary manifestation, making its appearance as the others are fading away, or after they have altogether disappeared. Sometimes, however, it runs its course contemporaneously with other secondary symptoms, and may even be the first to appear.

The hereditary cases of iritis mostly occur at about the time

FIG. 123.—Case of gummatous iritis, showing characteristic swelling at lower border of pupil. Pupil has dilated irregularly owing to synechiæ, and there is a trace of hypopyon.

of puberty, and in association with interstitial keratitis. Some few cases are met with in early infancy, or still more rarely in intra-uterine life.

It is as a rule difficult, or impossible, to detect from the mere inspection of the eye alone when the iritis is due to syphilis. One has therefore generally to be guided by the presence or absence of other secondary symptoms in arriving at a diagnosis, or by the history in cases where the iritis exists alone.

In some cases the inflammatory changes in the iris, which are usually of a plastic nature, bear strong evidence of their syphilitic

origin. Thus the development of more or less prominent yellowish vascularised nodules in the iris, or of localised tumefactions of the iris tissue, a condition known as *gummatous iritis* (see Fig. 123), is almost invariably due to syphilis. The gummata grow slowly, often causing very little pain or other evidence of inflammation until they have attained some size. Their vascularity increases as they grow, so that while at first they appear as yellowish spots, they later on change their colour to a dirty brown. It is this alteration in colour which in doubtful cases mainly distinguishes them from tubercles. The latter, too, are as a rule more numerous, and mostly spring from the peripheral part of the iris in the region of the angle of the anterior chamber, whereas the gummata show a greater preference to develop in the parenchyma surrounding the pupil. The gummata may undergo fatty degeneration and become absorbed, leaving no trace, or only a slightly depressed atrophic spot at the sites where they existed. In other cases they increase in size, growing into the anterior chamber, and lead, with or without perforation of the cornea, to shrinking of the eye—*phthisis bulbi*. The latter result is more uncommon than the former, and most likely to occur where the gummata originate in the peripheral portions of the iris, when they are frequently associated with the formation of similar nodules in the ciliary body.

Gummatous iritis does not, as the name might imply, belong as a rule to the tertiary period of syphilis, but to the secondary, although on the whole appearing rather later than the more common form.

Syphilitic iritis may occur in one or both eyes. No local cause can, as a rule, be given for its occurrence—there has been no trauma, no exposure to cold, etc.

In the treatment of syphilitic iritis it is well to begin mercury at once. Of the different ways of giving mercury, I have personally had most experience of inunction. The mercurial ointment should be rubbed well into the skin of the axillæ or inner side of the thigh for fifteen to twenty minutes once daily, and this continued for at least a month. A daily painting of the gums with a little tincture of myrrh, and frequent brushing of the teeth (not less than four times daily) with Condy's fluid, will almost invariably keep away any complication with stomatitis. But, of course, patients have to be carefully watched during this treatment, more especially as they have frequently already undergone mercurial treatment, before the onset of the iris inflammation. What I have seen, at the hands of French surgeons, of intra-muscular injections of the biniodide in syphilitic eye

affections generally, has led me to regard that method as a sufficiently efficient way of using mercury. I have, however, no personal experience of it, nor do I believe that, although more cleanly and perhaps less troublesome, it is in all respects quite as satisfactory as inunction. I should, however, certainly give it the preference over either internal administration or subcutaneous injection. Subconjunctival injection, so far as my experience goes, is also not to be recommended, at all events in iritis.

One practical point of some importance, as it necessarily influences the treatment which one adopts, is the question as to the diagnosis of syphilitic iritis. Owing to the frequency of rheu-

Fig. 124.—Case of gummatous iritis, showing numerous confluent swellings occupying the circumpupillary area of the iris, also a few spots of fibrinous exudation at the back of the cornea (descemititis).

matic iritis, and to the possibility of the resisting power of a syphilitic individual being no doubt more or less reduced, one may often have to ask one's self whether the mere fact of an individual who has at one time acquired syphilis, having an inflammation of the iris, is sufficient to justify the diagnosis of syphilitic iritis? There certainly seems to me to be too great a tendency in many quarters to ascribe an iritis to direct syphilitic causation wherever there is a syphilitic history, or even a reasonable suspicion of such a history.

Iritis occurring under other conditions in syphilitic individuals —for instance, a year or more after the primary symptoms, and

then it may be in one eye alone—should not be looked upon as so essentially syphilitic as to call for mercurial treatment. According to the patient's general condition or diathesis in other respects, salicin, iodide of potassium, or iron and quinine, are more suitable drugs to use, in addition to the necessary local treatment. It is well, too, always to remember that iritis is really an unusual complication in syphilis. The various statistics give proportions varying between 1 and 4 per cent. of all cases of syphilis. Inasmuch, too, as in many of the statistics no very critical distinction is made into secondary syphilitic iritis and iritis simply occurring in those who have been the subjects of acquired syphilis, the lower figure appears to me to more correctly express the actual proportion all round than the higher.

The forms of iritis already described, along with sympathetic iritis, which is discussed in the chapter on Sympathetic Ophthalmitis, are the main forms of the plastic variety. The association of plastic iritis with severe corneal inflammations, owing to the irritation of toxins formed in the inflamed area, has already been referred to.

Serous iritis.—This variety of iritis, which receives its name on account of the exudation being on the whole more serous than fibrinous, is almost invariably associated with a cyclitis or choroiditis. It is, therefore, properly speaking an irido-cyclitis. It is much more frequent in women than in men. According to Horner the proportion in the two sexes is as ten to three. Corresponding to the comparative absence of a plastic exudation, serous iritis is a less painful, more insidious, and usually more chronic affection than most of the forms of plastic iritis. The irritation it produces is indeed often so slight, that the attention of the patient is first called to the eye by the certain degree of haziness of vision to which it gives rise. The back of the cornea is then found, on examination, to be covered, mainly in its lower quadrant, by a number of minute brownish specks, while the aqueous humour is at the same time more or less turbid. The circumcorneal injection is usually slight and most marked at the lower part, with a great tendency, however, to become more apparent if the eye be kept open for some time, or if it be rubbed.

The small deposits which lie on the membrane of Descemet, consist mainly of pigment, along with leucocytes and fibrin. This condition often receives the name of keratitis punctata, although it is not, properly speaking, a keratitis. Descemetitis is another term applied to the same appearance (see Fig. 125). The pigment evidently comes from cells, and is not altered

blood pigment. The larger spots are due sometimes, it would appear, to proliferation as well of the underlying cells of Descemet's membrane.

In the first stage of the inflammation there are no synechiæ, or only very trifling ones. Often a very distinct hyperæmia of the papilla is to be made out with the ophthalmoscope. In the majority of cases synechiæ begin to form after the inflammation has continued for some weeks. At the same time the hyperæmia of the papilla becomes more marked, and diffuse white floating opacities make their appearance in the vitreous. These changes are accompanied by alterations in the intra-ocular

FIG. 125.—Case of serous irido-cyclitis, showing deposits at back of cornea arranged in characteristic triangular form.

tension, which is first increased, and afterwards very often considerably diminished.

The *prognosis* in this form of iritis depends much on the general health of the patient, as well as, of course, on the extent to which the uveal tract as a whole has participated, and on the completeness of the synechiæ. A number of cases end in complete recovery, but more frequently the recovery is incomplete. In some cases only slight changes in the vitreous occur at all, so that recovery takes place after the inflammation has remained for some time in the first stage, the symptoms being mainly confined to the anterior portions of the eye. In others, again,

the more or less dense vitreous opacities clear away after longer or shorter periods, and no further harm results, if the formation of synechiæ has been obviated by keeping the pupil dilated. Owing however, no doubt, to the alterations which the uveal inflammation brings about in the nutrition of the eye, there is a tendency, in cases where opacities of the vitreous have been marked and persistent, towards the gradual development of cataract, usually posterior polar cataract. The worst cases are those in which extensive synechiæ have formed, with occlusion of the pupil, and the termination, as in other forms of iritis, either in secondary glaucoma, or detachment of the retina, with shrinking of the eye.

The *etiology* of serous irido-cyclitis is not always very clear. The preponderance of cases in women, already referred to, shows that syphilis cannot be, at all events, a general cause. Probably Horner's view is the correct one, that it results from some pathological condition of the blood or blood vessels. He points out, for instance, that it is this variety of iritis which is apt to occur after fevers or severe illnesses. Often there are menstrual disturbances, or actual disorders of the sexual organs, in women affected with this disease; all are more or less anæmic or chlorotic. When it occurs in men, they are for the most part, ill-nourished and anæmic.

In the *treatment* greater care must be taken than in the case of the plastic variety of iritis not to use atropine too freely, on account of the tendency there is towards increased tension. The pupil should at first be kept dilated, or semi-dilated, with as weak a mydriatic as possible. When the deposits at the back of Descemet's membrane are numerous and large, it is well to perform paracentesis of the cornea, taking care not to allow the aqueous humour to escape too rapidly. The tapping of the anterior chamber may be frequently repeated if undertaken with proper antiseptic precautions. It appears to have a beneficial influence on the inflammation, and to favour the absorption and disappearance of the exudation into the vitreous as well. When these vitreous opacities are dense, wet packing and subcutaneous injections of pilocarpine are often of use in promoting absorption. Where there is marked increased tension, especially in elderly people, I have found sclerotomy performed with the triangular-shaped knife (keratome) of great use. The absence of pain, or of any tendency to aggravation from cold, render it unnecessary to take particular precautions to keep the patient's surroundings at an equable temperature. Indeed, in most cases open air and moderate exercise is desirable, especially in summer. Proper

regulation of the action of the bowels should never be neglected, and iron in some form given. I have found the natural iron waters, such as Flitwick or Levico, useful, and in summer prescribe these to be drunk slowly outside before breakfast, and in the afternoon, in all cases where the conditions render this possible. Five-gr. doses of chloride of calcium may in some cases be followed by rapid improvement. Turkish baths are also useful. After fevers, iron and quinine, and a generous diet, with regular intervals of rest, are indicated.

Traumatic iritis.—*Purulent iritis.*—Iritis may be set up by direct injury to the iris, or by injury to the contiguous parts of the eye—the cornea, lens, or ciliary body. The injury may be an accidental one, or be caused by some operation, such as the extraction or discission of a cataract. The severity of the inflammation depends greatly upon whether or not septic matter or any foreign body has remained in the eye. These almost invariably give rise to a purulent inflammation. The pus which is then excreted from the inflamed iris not only infiltrates its tissues, collecting mainly between the endothelial covering and the stroma, but also falls to the bottom of the anterior chamber as hypopyon. At the same time some of the vessels give way, causing hæmorrhage into the iris.

Purulent iritis may, too, form only a part of a general suppurative destruction of the eye, the result either of external local changes, or of septic emboli in the choroid. Sometimes a traumatic iritis does not occur at all, or only slightly, at the time of an injury, but is set up at some subsequent period by changes which occur in the eye, and lead to persistent dragging on, or irritation of, the iris.

The *treatment* of traumatic iritis will depend greatly upon the nature of the injury as well as upon the severity of the inflammation. If the lens has been wounded, or if a foreign body be lodged in the iris or in the anterior or posterior aqueous chamber, some operative interference will usually be called for. Where there is no foreign body, but where the nature of the accident and the presence of much hypopyon render the septic character of the inflammation undoubted I have found the subconjunctival injection of fully saturated, freshly prepared chlorine water the most satisfactory treatment. In a number of cases improvement begins then at once, with the rapid disappearance of the hypopyon, and is generally continuous. Only comparatively rarely does the injection have to be repeated when a good result has followed the first injection of 15 to 20 drops in two or three different places round the cornea.

Tuberculous iritis.—This is a rare form of iritis, though probably more frequent than used to be supposed, which may occur in one or both eyes, and most commonly makes its appearance before the period of full growth. The inflammation begins as an ordinary serous or plastic iritis, and is often preceded by ill-health and loss of flesh, and accompanied by, sometimes very considerable, swelling of the surrounding lymphatic glands. Tubercles in the shape of small yellowish nodules, usually in considerable numbers, make their appearance, and the iritis shows a tendency to become chronic. The tubercles may become

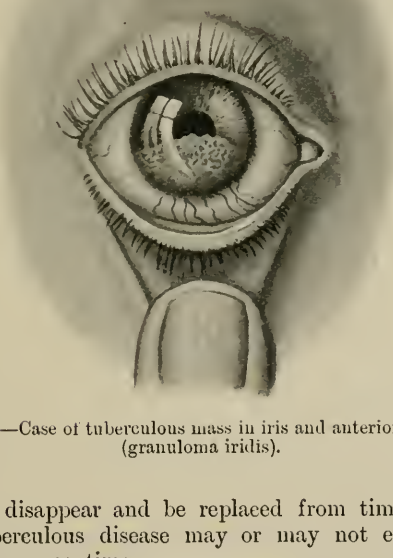


Fig. 126.—Case of tuberculous mass in iris and anterior chamber (granuloma iridis).

confluent, or disappear and be replaced from time to time by others. Tuberculous disease may or may not exist in other organs at the same time.

Some cases completely recover; others, again, lead to shrinking of the eye, or to perforation and protrusion of a tuberculous mass externally. There is seldom any difficulty in the *diagnosis*. Gummata of the iris, which they somewhat resemble, are more vascularised, and occur, besides, at a different time of life.

In the *treatment*, the possibility of the disease in the iris acting as a source for self-infection must always be kept in view.

This danger is apparently greatest in the cases of granuloma which lead to perforation, but it is also present in the form which ends in phthisis of the globe. There can be no doubt, therefore, that the proper treatment in the worst cases is enucleation. In some cases an isolated tuberculous mass may be excised (along with the portion of iris in which it is situated), but this treatment is only rarely successful. The iritis must be treated on the ordinary lines, and the patient's strength kept up by nourishing food, and the exhibition of anti-strumous remedies.

Cyclitis.—Inflammation of the ciliary body, or cyclitis, is best considered in this connection, as it is so frequently associated with iritis. This association is probable in all cases in which there are deposits in the posterior surface of the cornea. It is certain where there are changes in intra-ocular tension, whether that be increased or diminished. Often in cyclitis there is a very marked diminution in tension. Cyclitis is also certainly present along with iritis when the degree of visual disturbance is greater than can be accounted for by the visible changes in the pupil and anterior chamber.

The character of the exudation from the inflamed ciliary body may, as in the case of iritis, be mainly serous, or it may be plastic or purulent, and the symptoms may differ more or less accordingly. The exudation passes from the two free surfaces of the ciliary body into the posterior aqueous chamber and into the vitreous chamber.

A constant symptom of cyclitis is therefore more or less intransparency of the vitreous. Often this can only be inferred from the defect of vision which it produces, as, owing to the presence of synechiæ, and the difficulty of obtaining dilatation of the pupil, the objective determination of the opacities may be a matter of difficulty. The exudation from the anterior portion of the ciliary body leads to synechiæ, precipitations on Descemet's membrane, obliteration of the pupil, and, in bad cases, to an agglutination between the posterior surface of the iris and the capsule of the lens. In the case of purulent cyclitis there is also hypopyon.

That portion of the exudation of plastic or purulent matter which passes through the ciliary processes into the vitreous chamber may remain confined to the immediately surrounding regions, or may permeate the vitreous more or less extensively, causing it to become more liquid. If absorption does not rapidly take place, changes occur in the exuded matter leading to the formation of filamentous or even membranous shreds of a

low form of connective tissue. Where there has been an excessive exudation, the subsequent shrinking and liquefaction which takes place may result in detachment of the retina, and consequent complete loss of vision. In many cases, where the exudation has accumulated at the anterior portion of the vitreous, subsequent contraction, taking place during its organisation, leads to displacement of the lens. Most frequently this displacement is forward, so that the anterior chamber becomes more or less shallowed; sometimes, owing to the contraction being more in one direction than in others, some portion of the lens is tilted forward, and the chamber is shallowed in one direction and deepened in the opposite.

In some old-standing cases the anterior chamber is deepened, so that a funnel-shaped depression is observed to exist at its centre. This is produced by contraction in an antero-posterior direction, which brings about an approximation of the lens and the optic papilla, to which the organised exudation has formed an adhesion. In such cases there is at the same time diminution in the intra-ocular tension.

Cyclitis may be set up traumatically, or by some alteration taking place within the eye. A severe blow on the eye may be sufficient, but more common causes are penetrating wounds, and the introduction of foreign bodies either into the ciliary body itself, or into some of the surrounding parts. In some cases where foreign bodies have become encapsuled, they may become suddenly dislodged, and then set up cyclitis months or years after the accident which drove them into the eye. It may be that, having lodged in the lens, thus producing traumatic cataract, the gradual disintegration and absorption of the lens leads to an alteration in the position occupied by the foreign body. The new position is apt to be one which causes more irritation of the tissues of the eye and cyclitis.

Traumatic cataract alone, *i.e.* without the presence of any foreign body, may in various ways set up cyclitis. This may happen if a rapid swelling takes place where the lesion in the capsule has been small, and the swollen lens matter does not readily make its escape into the aqueous chamber. Again, it may happen if the iris, owing to its having formed adhesions to the wound in the capsule, is subjected to more or less constant dragging. A dislocated lens is also very apt to set up cyclitis, more especially if it has at the same time undergone advanced degenerative changes.

While irregular and septic wounds in the ciliary region almost invariably lead to an immediate and usually purulent cyclitis,

very little irritation may result from clean and aseptic wounds in the same situation.

Wounds of the ciliary region should be carefully washed with some antiseptic lotion, and any separation of the lips as much as possible prevented by cutting off or replacing the intervening structures. Swollen lens matter, when causing irritation, must be removed in the manner described at p. 208. A dislocated lens must be extracted, and where any dragging on the iris has set up irritation, or appears likely to do so, it will be necessary to perform iridectomy in such a position as to free if possible the portion dragged upon.

When cyclitis is once set up, the treatment should consist in keeping the pupil dilated with atropine, in applying hot fomentations to the eyes, and in leeching over the temples. The eyes should be shaded, and the patient not allowed to read, or to use his eyes for any near work. In purulent cases it is well to apply a pretty tight bandage over the affected eye, as this seems to aid in checking the tendency to panophthalmitis—that is, to an extension of the purulent inflammation to the choroid.

Tumours of the iris.—Both simple and malignant tumours are met with in the iris. They are rare, and not of particular interest. Two kinds of cyst occur—the *epidermoid* and the *serous*. The former only appears to come after there has been some penetrating wound of the cornea, and the latter is usually also of traumatic origin. The proportion of traumatic cases is at least four in five. At the time of the accident some small portion of skin or corneal epithelium, or a piece of an eyelash, is driven into the anterior chamber, and there proliferates, assuming usually a cystoid type of growth. The time elapsing between the accident and the formation of an epidermoid cyst is at least two months, and may amount to several years.

The serous cyst seems mostly to extend from the margin of the anterior chamber. It is, in fact, a kind of cystoid degeneration of the iris, leading to the formation of a diverticulum at the angle of the chamber.

The prognosis is bad in both these forms of cyst, as they are apt to go on growing, and eventually lead to destruction of the eye.

The *treatment* consists in excising them as soon as possible, along with the portion of iris to which they are attached. Care should be taken not to rupture the cyst wall during removal. But it is by no means always possible to avoid this.

Like other parts of the eye, the anterior chamber may be visited by a *cysticercus*. In the cases which have been observed, and which have occurred almost exclusively in Germany, the surrounding cyst has sometimes been clear, at other times purulent.

Sarcoma of the iris is usually but not always an extension from the ciliary body, which is a common site for malignant tumours within the eye. It may be pigmented (melanotic) or not. Only in the latter case is there any possibility of mistaking it for a gummatous or tuberculous mass. Its early diagnosis is a matter of importance.

Alterations in the iris produced by injury.—Lacerations of the iris may be produced by penetrating wounds. When the

Fig. 127.—Cyst of the iris after injury.

history of the accident points to the impaction of a small body, the appearance of the laceration of the iris is strongly suggestive of its presence somewhere in the eye. Sometimes the laceration has taken place at the pupillary margin,—more frequently, however, it is elsewhere; and the more peripheral it is, the more importance does it acquire from a diagnostic point of view, when the question arises as to whether or not a foreign body is lodged in the eye. With the more central wounds there may usually be made out the corresponding wound in the lens; while in the case of peripheral wounds of the iris, a trauma of the lens is neither of so frequent occurrence, nor so easy of observation when it has occurred. The laceration may cause bleeding,

which is usually slight, and rapidly absorbed. Synechiæ almost always occur in cases where the wound is situated not far from the pupil, unless the pupil has been well dilated soon after the accident.

A simple wound of the iris is not likely to cause iritis, but when, as so often happens, the lens is wounded at the same time, or a foreign body is lodged in the eye, the chances of inflammation being set up in the iris are very great. The *treatment*, too, will vary according to the severity of the accident. When the iris alone is injured, a few days' dilatation of the pupil with a mydriatic and rest to the eyes is all that is usually required.

Various *injuries to the iris* are produced by blows on the eye; the simplest of these, though not the most frequent, is a rupture of the sphincter muscle. Sometimes a rupture takes place in the direction of the radial fibres of the iris, but without involving the sphincter. This, too, may occur spontaneously in cases where the iris is atrophic, and dragged on in some particular direction.

A more common accident, produced by severe contusions, and often associated with rupture of the choroid, is a separation of more or less of the iris from its peripheral or ciliary attachment. This accident (see Fig. 128), to which the name of *irido-dialysis* is given, is always accompanied at the time by hyphæma. It may occasion uniocular diplopia, if the eye, from an error of refraction or owing to the state of accommodation, is not focussed for the object looked at. The separation causes a flattening of the corresponding portion of the pupillary margin.

All degrees of irido-dialysis are met with. When very slight, it can only be easily diagnosed by reflecting light into the eye, when the red colour of the fundus can be seen at the periphery of the iris, as well as through the pupil. A spontaneous re-attachment of the iris to the ciliary body practically never occurs. Occasionally, in performing iridectomy, if the iris is too forcibly drawn upon by the forceps, a separation occurs at its periphery.

Another and very curious result of blows on the eye is the complete or partial *retroversion* of the iris. This gives rise to the appearance of a complete absence of any iris at the position of the lesion. When partial, it is usually possible to see the folding of the iris, where the inverted portion joins on either side the portions which remain *in situ*. The existence of the folded-back portion can also be inferred from the fact that the ciliary processes are not visible with the ophthalmoscope, not-

withstanding that no iris intervenes between the cornea and the margin of the lens.

Temporary or permanent *dilatation of the pupil* may also result from a blow on the eye. Often the dilatation is irregular.

Where the lens is dislocated or absent, and thus the natural support which the iris gets by its apposition to the capsule in the normal state is interfered with, or altogether lost, the iris is observed to shake with the movements of the eye. This tremulous condition of the iris is called *iridodonesis*. It should direct attention to the lens, an abnormality in which is the most

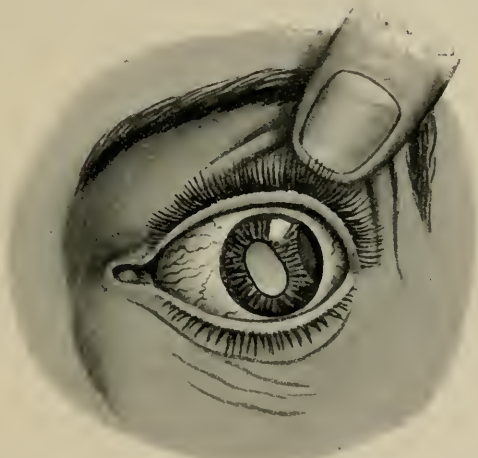


FIG. 128.—Case showing separation of iris from its peripheral margin (irido-dialysis), caused by a blow which was also followed by cataract.

common cause, though sometimes a not inconsiderable degree of shaking may occur in cases where, from some cause or other, the posterior aqueous chamber is unusually deep.

In old cases of iritis, especially if complicated by any condition which gives rise to constant dragging on the iris, *atrophy* of the iris takes place. The tissues may be so thin as to admit of more or less light passing through from the fundus on ophthalmoscopic examination ; often there are actual rents here and there. Atrophy of the iris is common in the last or degenerative stages of glaucoma.

Congenital anomalies of the iris.—*Coloboma of the iris* (see Fig. 129) is a congenital defect, which is due to non-closure of the fœtal fissure. It may or may not be associated with a similar congenital defect in the choroid. The coloboma may be of all sizes, up to one-fourth of the whole iris. It always occurs downwards, or downwards and inwards, and generally, though often not to the same extent, in both eyes. It may be either total or partial—that is to say, it may extend right up to the ciliary body, or close before reaching so far back, or may even be bridged.

Closely allied often to coloboma of the iris is the condition known as *correctopia*, or eccentric displacement of the pupil. Owing to faulty development of the muscular fibres of some portion of the iris and ciliary body, the pupil becomes drawn

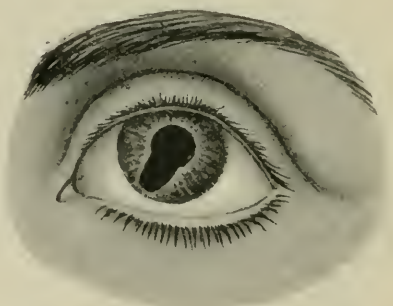


Fig. 129.—Congenital coloboma of the iris (inwards and downwards).

up, from the preponderance of action of the more complete portions.

Aniridia.—Not so common as coloboma, but still not of very rare occurrence, is a congenital absence of the iris—*aniridia*, or *irideremia*. This condition is most commonly met with in several members of the same family, and is inherited. It almost invariably occurs in both eyes. The appearance which the total absence of the irides gives to the eyes is peculiar, and not altogether like that which most resembles it, namely, maximal dilatation of the pupils. In all cases which have come under my own observation there has been at the same time a ring of pigmentation in, or immediately behind, the peripheral portion of the cornea. In many cases there is some defect in the lenticular system,—either congenital displacement of the lens, due to

some faulty development of the suspensory ligament, or more or less opacity. Myopia, or defective accommodation, are frequent concomitants, and there is usually as well more or less defect of sight. Patients with this defect are bothered by dazzling, and acquire the habit of screwing up their eyes. There is often at the same time photophobia, and, in the cases where the associated defects are most marked, nystagmus.

Albinism.—The general absence or defective development of pigment throughout the body, which characterises the albino, gives to the iris a very peculiar appearance. It has usually a pinkish or faint lavender colour, and the details of its structure are more evident than in an iris in which there is a normal

Fig. 130.—Congenital coloboma of the iris.

amount of pigment present. When the eye is examined with the ophthalmoscope, a considerable amount of light, reflected from the fundus, is found to pass through the iris, and it is this translucency, as well no doubt as the associated absence of pigment in the choroid, which gives rise to the dazzling from which albinos suffer, and which causes them constantly to screw up their eyes. The vision is more or less imperfect, and there is some degree of nystagmus in all cases. Some cases are met with where the pigment is not altogether absent. In these there seems, as a rule, to have been a gradual development of pigment since birth, with a corresponding improvement of vision. Albinism is sometimes met with in several members of the same family.

Little can, as a rule, be done to improve the sight. Some find comfort, without any visual improvement, by the use of darkened glasses. Stenopaic apertures are only useful in cases where the nystagmus is slight.

The iris of the new-born infant is grey or blue in colour, and either remains so, or gradually accumulates pigment, so as eventually to become more or less brown. These changes take place, as a rule, very early in life, but are sometimes deferred till the third or fourth year, or even later.

The influence of heredity on the colour of the eyes is very marked, and there seems no greater tendency to inherit from either parent. It has been found, for instance, that of the offspring of parents with differently coloured irides—that is, the

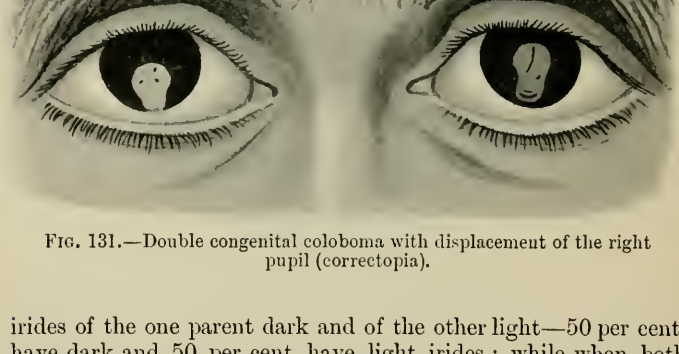


Fig. 131.—Double congenital coloboma with displacement of the right pupil (correctopia).

irides of the one parent dark and of the other light—50 per cent. have dark and 50 per cent. have light irides; while when both parents have light or dark irides, 96 per cent. of the offspring present the same colour as the parents, and only 4 per cent. not. Of these 4 per cent., most have both eyes the same, inheriting probably from some more remote ancestor; while a few present the appearance known as *heterochromia*, where the one iris is brown and the other blue.

In normal eyes the pupillary membrane, which, during the greater part of intra-uterine life, stretches across the pupil, only remains persistent in that part which covers the iris, whose endothelial layer it becomes. It is not a very uncommon thing to find, however, small portions of the membrane stretching across the pupil in the shape of one or more fine threads. To

this condition the term *persistent pupillary membrane* is applied. Occasionally a considerable portion of the membrane persists, and is adherent to the capsule of the lens, usually at the same time having filamentous attachments to the iris. This membranous form produces considerable defect of vision, while the more common filamentous form is of no importance whatever in this respect. Without careful examination, the fine threads might easily be taken for fibrinous remains of an old iritis, but they can be distinguished from these by observing that they spring from some portion of the anterior surface of the iris, usually by two or more fibrous roots, while an iritic exudation comes from the lower surface of the iris, or at most adheres to the pupillary margin. Only the rare membranous form calls

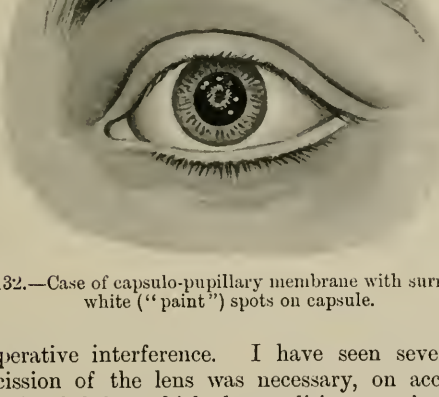


FIG. 132.—Case of capsulo-pupillary membrane with surrounding white ("paint") spots on capsule.

for any operative interference. I have seen several cases in which discission of the lens was necessary, on account of the amount of visual defect which the condition occasioned.

ANTERIOR CHAMBER.

Individual differences exist in healthy eyes in the depth and shape of the anterior chamber. Changes are also continually taking place in health, according to the state of accommodation. When the eye is accommodated for near objects, the middle of the chamber is shallower, and the periphery deeper, than in the case of accommodation for distance. In very young infants and very old people the chamber is shallower than at other periods of life. In the former case this

is owing to the globular shape of the lens and the imperfect development of the eye altogether; in the latter, to increase in the size, and possibly also to advancement, of the whole lens.

The anterior chamber is pathologically increased in depth in two ways: by an alteration in the normal position of the lens, and by a change in the normal curvature of the cornea. Thus we often find a deep chamber when the lens is absent or dislocated, and also when it is pushed backwards by excessive secretion; or when a retraction takes place, owing to the shortening of organised exudation in the vitreous chamber. It is abnormally deep, too, in cases of conical cornea, cornea globosa, and staphyloma of the cornea.

Diminution in depth of the anterior chamber results from causes which lead to advancement of the iris or lens, or flattening of the cornea. Exclusion and occlusion of the pupil give rise to an accumulation of aqueous humour behind the iris, which is consequently pushed forward, and the chamber in that way shallowed. Shallowing of the chamber is also met with in glaucoma, and in the second stage of intra-ocular tumours. In old cases of irido-cyclitis, too, and in some cases of detached retina, the anterior chamber is shallowed, owing to atrophy of the vessels of the iris and ciliary body, and a consequent diminution in the secretion of aqueous humour.

Alteration of the *shape* of the chamber—retraction of the periphery and advancement of the pupillary portion of the iris—is met with, and is an important point in the diagnosis of metastatic choroiditis in children, or what has been called *pseudo-glioma.*

The *contents* of the chamber, too, are subject to pathological alterations. Thus the normal clearness of the aqueous is disturbed in many cases of iritis. Dislocation of the lens may also take place into the chamber. Along with septic inflammation of the cornea, or purulent iritis, or cyclitis, pus may collect in the chamber (hypopyon). Injuries to the vessels of the ciliary body, or iris, may lead to a collection of blood (hyphæma). Finally, foreign bodies may lie in the anterior chamber, and may or may not be surrounded by purulent exudation, according to their nature and the time they have been in the eye.

CHAPTER X.

DISEASES OF THE CHOROID AND VITREOUS.

The Choroid.

A certain portion of the choroid, namely, that which lies anterior to the equator of the eye, is altogether hidden from view. Pathological changes affecting this portion can therefore only be inferred from the symptoms to which they give rise. The rest of the choroid is also more or less concealed by the pigment contained in the hexagonal cells of the retina. When this pigment is scanty, the larger vessels of the choroid, as well as the intervascular spaces, are visible on account of the transparency of the rest of the retina.

The blood supply to the choroid is mainly through the short posterior ciliary arteries, of which there are about twenty. These vessels enter in the vicinity of the optic nerve, at the back of the eye, and do not anastomose to any extent with each other. They form, however, pretty free anastomoses with the recurrent branches of the long anterior and posterior ciliary arteries. A considerable portion of the anterior part of the choroid is therefore supplied by these long arteries, and either by branches from the trunks themselves, or from the arterial rings which they form in the ciliary body.

The blood returns through veins, the arrangement of which is very different from that of the arteries. The venæ vorticosæ, from four to six trunks, collect all the blood from the choroid, as well as much which has supplied the anterior portions of the eye. The numerous choroidal veins mainly join these trunks, which pass out of the eye near its equator. Some open into anastomoses, which are formed here and there between the contiguous vortex veins behind the equator of the eye.

The choroid is only firmly adherent to the sclera behind at the entrance to the optic nerve, and anteriorly through the ciliary body. The attachment to the sclera in other situations

is merely through the vessels which penetrate that membrane to reach the choroid. The pigment layer of the retina adheres closely to the choroid, so that when the retina becomes detached it leaves this layer behind.

Choroiditis.—As the extent to which the normal choroid is visible with the ophthalmoscope depends on the condition of the hexagonal pigment cells, so also does the visibility of pathological changes in the choroid. Considerable alterations may have taken place where there is yet nothing to be seen with the ophthalmoscope; indeed, in some instances, it is only when the pathological process in the choroid involves the retinal pigment cells that ophthalmoscopic changes are observed. Strictly speaking, then, in the case of inflammations of the choroid, characteristic ophthalmoscopic appearances are only seen when the retina is involved as well—that is, when the condition is one not only of choroiditis but of *choroido-retinitis*. From a clinical point of view, however, an inflammation beginning in the choroid, though afterwards spreading to the outer portions of the retina, is a choroiditis. Such inflammations have altogether a different origin from cases of true retinitis, or inflammation of the nerve elements, or of the connective tissue of the retina.

Choroiditis, besides causing retinal changes, may give rise to more or less marked changes in the transparency and consistency of the vitreous. In certain forms, too, the sclera is at the same time weakened, so that alterations in the shape of the eye take place, leading to more or less disastrous consequences.

There is a great tendency to a patchy arrangement in choroidal inflammation, or to what is called disseminated choroiditis, but in some cases, and more especially in the serous and purulent varieties, the inflammatory changes are diffused over the whole membrane.

Disseminated choroiditis.—The ophthalmoscopic appearances met with in disseminated choroiditis are due to localised exudations into the choroid, alterations in the retinal pigment, and eventually also to atrophy of the choroidal stroma. The patches of exudation and degeneration, which sooner or later become visible, vary greatly in shape and size. They are often approximately circular, but they may be of any other form, not unfrequently crescentic, or dumb-bell-shaped. By their confluence they assume all kinds of irregular forms. They differ in appearance according to the stage arrived at by the inflammation. Different foci of inflammation may exhibit different stages at the same time. In the beginning the spots are yellowish, or

reddish yellow, and show little or no trace of choroidal vessels. Their margins are not very sharply defined, and there is occasionally some degree of prominence evident. These appearances correspond to the stage of hyperæmia and exudation. Old-standing patches, which have reached what may be called the degenerative stage, are white, with traces of the remains of choroidal vessels, and they are not prominent; their margins are sharply defined, even punched-out looking, and often bordered with pigment. The white appearance of the patches is due not

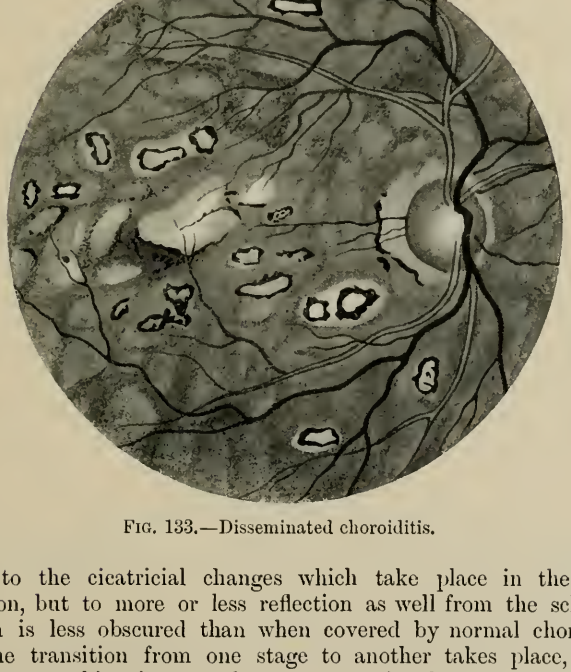


FIG. 133.—Disseminated choroiditis.

only to the cicatricial changes which take place in the exudation, but to more or less reflection as well from the sclera, which is less obscured than when covered by normal choroid. As the transition from one stage to another takes place, the change to white is seen first to occur in the centre of the patches.

While the appearances just described enable one to distinguish the evident exudative from the evident degenerative stages, there are many cases where the diagnosis of the stage is by no means easy, and may be impossible. This is the case mainly

where the principal changes seem to be limited to the pigment layer of the retina. The choroidal structure is then well seen in the area of the patches, and the main difference, caused by time, is in the amount and arrangement of the pigment masses bordering them.

In a not uncommon variety of disseminated choroiditis, one which seems usually to be a manifestation of hereditary syphilis, the patches are small, circular, and bordered by dense crescentic masses of pigment. In some cases of choroiditis the pigmentary

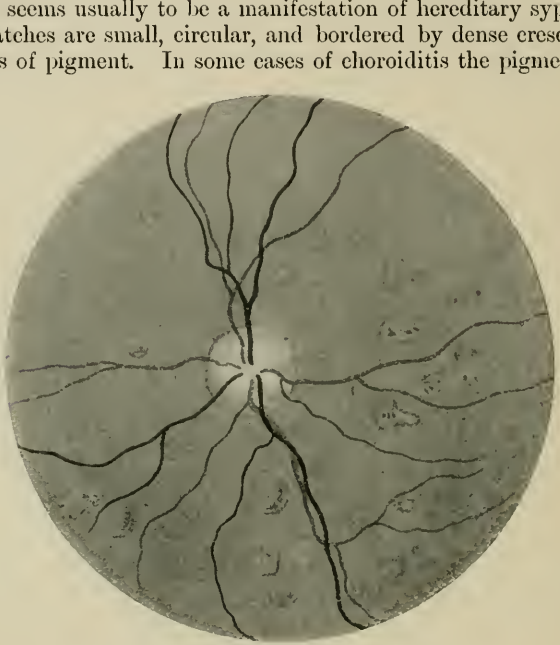


Fig. 134.—Recent disseminated choroiditis.

changes are not limited to the region of the patches in the choroid, but are met with in the shape of irregular spots in the more superficial parts of the retina.

Choroidal patches may form first in the region of the equator of the eye, and gradually invade more and more of the choroid, spreading towards its central portion, as well as anteriorly; or they may be confined to the region of the papilla and macula.

It is hardly possible to say, from the ophthalmoscopic appearances in any case of disseminated choroiditis, to what extent the vision has been reduced. In many cases the most extensive ophthalmoscopic changes are met with where the visual acuity

is found on examination to be hardly, if at all, subnormal. Often, however, in such cases where the vision is found to be so good, there is some degree of night blindness and cloudy vision. The subjective symptoms are altogether more marked in the exudative than in the atrophic forms of the inflammation, the occurrence of fresh patches of exudation being accompanied by subjective sensations of light and colour, as well as by positive scotomata. The degree of visual disturbance and other subjective symptoms depends in great measure on the site occupied

FIG. 135.—Circumscribed central choroido-retinitis in atrophic stage, showing also annular staphyloma posticum.—After WECKER and MASSELON.

by the patches of inflammation. Patches at or near the macula necessarily cause much greater interference with vision than those situated more peripherally. Frequently the vision, which has hitherto been more or less good, all at once becomes very much deteriorated, without any marked change being visible in the ophthalmoscopic appearances. The reason of this is, that a fresh patch has formed at the fovea, or, it may be, a previously existing change in that situation has so far

altered as to involve the percipient elements of the retina, which up to that time have escaped.

Central patches give rise at first to distorted vision, or *metamorphopsia*. At a later stage this may be followed by a positive scotoma, or a blind spot, of which the patient is conscious, and which he projects in front of his eye as a clouded or black figure, the size of which increases with the distance of the plane of projection. The scotoma is at first only seen in subdued light, and clears away as the surrounding illumination becomes greater, or

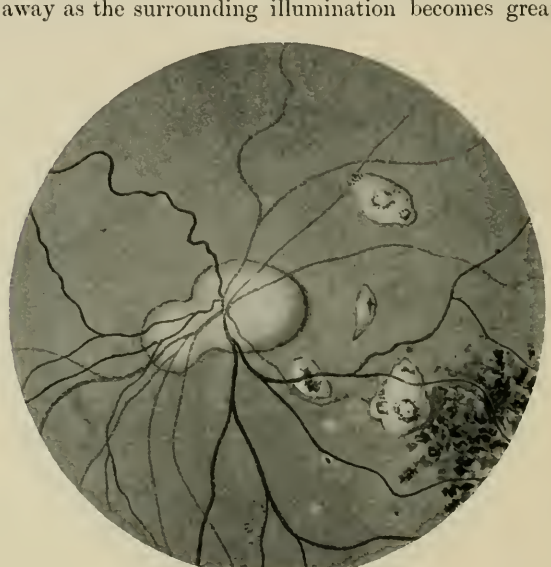


FIG. 136.—Disseminated choroiditis showing marked pigmentary changes.

the object fixed is brighter. In testing for positive scotomata, therefore, the test should be made in subdued light.

The metamorphopsia is due to a change, produced by the exudation or other alteration of the choroid, in the relative positions of the percipient elements of the retina, which causes a difference in the external projection of the impressions which they receive. In the case of a fresh exudation, the retinal elements are abnormally separated, so that a smaller number of them come to occupy the same superficial area as before; or, in other words, the same number of elements are spread over a larger area than under normal conditions. The image of any

object falling on such an area produces stimulation of a smaller number of retinal elements than it would otherwise do; but the projection being unaltered, this is not compensated for, and the object appears diminished—that is to say, such changes give rise to *micropsia*. On the other hand, the shrinking resulting from the contraction of an old exudation, or from some atrophic change, may lead to a greater approximation of the retinal elements in the area involved, so that the same number

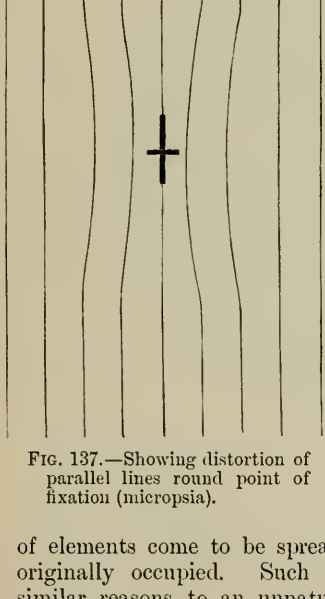


FIG. 137.—Showing distortion of parallel lines round point of fixation (micropsia).

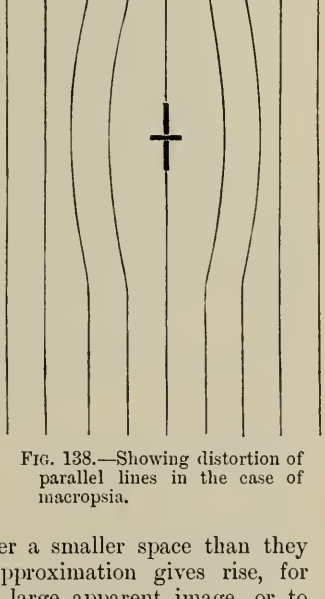


FIG. 138.—Showing distortion of parallel lines in the case of macropsia.

of elements come to be spread over a smaller space than they originally occupied. Such an approximation gives rise, for similar reasons, to an unnaturally large apparent image, or to *macropsia*.

The best method of testing whether or not any metamorphopsia exists (and it may be present without being spontaneously complained of) is to cause the patient to fix a mark in the middle of a number of parallel lines, a few millimetres apart, and to say whether they appear to him to run parallel, or to

bend outwards or inwards at any particular place. In this way we may detect not only the existence of a localised metamorphopsia, but also whether we have most probably to do with a recent exudation causing a distension, or an old exudation or atrophic change which has led to a contraction and approximation of the retinal elements in the corresponding area.

Besides the defect in visual acuity caused by changes in the external layers of the retina, there may be other changes which have more or less influence on the vision, according to the site of the choroidal exudations. When the area attacked is in close proximity to the papilla, there is often found to be hyperæmia of the disc, with some interference with the transparency of the vitreous. This hyperæmia is the result of a participation by the scleral vascular ring in the congestion of the choroidal vessels. Again, an extension forwards of the inflammatory changes is apt to bring about a complication with cyclitis or even iritis. What the exact connection is between choroiditis and opacities of the vitreous is not very clear, more especially why such opacities should occur in some cases and not in others.

The *etiology* of disseminated choroiditis is very often obscure. A number of cases, and more particularly of the exudative variety, are probably syphilitic. It is very uncommon in children, in whom it is mostly a manifestation of inherited syphilis. There seems reason to suspect that some cases, particularly those occurring in young adults, are of tuberculous origin.

Treatment.—In the cases which are of syphilitic origin, antisyphilitic treatment, on the lines referred to in connection with syphilitic iritis, will often be found to be of use. But great harm may be done by treating other cases in the same way. This is more particularly so where the choroidal inflammation occurs in young people or comes on after some debilitating illness. Fresh air and moderate exercise with tonics, especially iron, are most useful in such cases. It is certainly a mistake to confine such patients to a more or less darkened room, as is often done. They may be given dark glasses to wear outside, but should not as a rule be put under any more severe restraint. Wet packing for half an hour every morning sometimes appears to do good.

Senile central choroiditis.—When the vision of old people slowly but steadily deteriorates, and when on examination it is found that the field of vision is normal in extent in all directions, while with the ophthalmoscope the lens and vitreous are

seen to be clear, a careful exploration of the macular region should be made. For this purpose it is generally necessary to dilate the pupil. The cause of this progressive defect will, in such cases, very often be found to be an alteration in the choroid immediately behind the macula.

If seen at an early stage the appearance presented by this disease is that of a reddish or reddish-yellow, usually irregularly oval-shaped, patch, often only very slightly differing in colour from the rest of the fundus, but always presenting a very definite outline. Afterwards the patch assumes a more atrophic

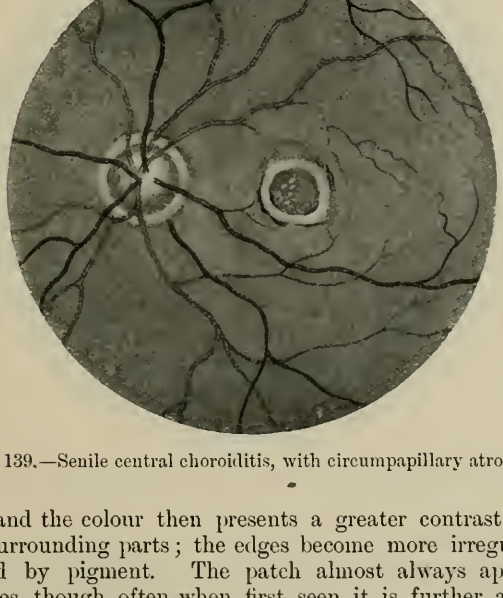


FIG. 139.—Senile central choroiditis, with circumpapillary atrophy.

aspect, and the colour then presents a greater contrast to that of the surrounding parts; the edges become more irregular and bordered by pigment. The patch almost always appears in both eyes, though often when first seen it is further advanced in one eye than in the other. As a rule it is little more than half the size of the papilla, but it may be considerably larger.

The condition gives rise to metamorphopsia, and to the appearance of a positive scotoma, of the existence of which the patient is more or less conscious. Central fixation is eventually abolished, so that the visual acuity is reduced to $\frac{20}{200}$ or less. Patients with central choroiditis are therefore unable to read

ordinary print, but do not become quite blind, as there is no tendency for the condition to spread to other parts of the eye. On this account the *prognosis* is so far good, and it is therefore of considerable practical importance to make a correct diagnosis, and not confound the condition with any affection which may possibly proceed to blindness.

No *treatment* appears to have any influence whatever on this disease.

Syphilitic choroiditis.—While many changes recognised with

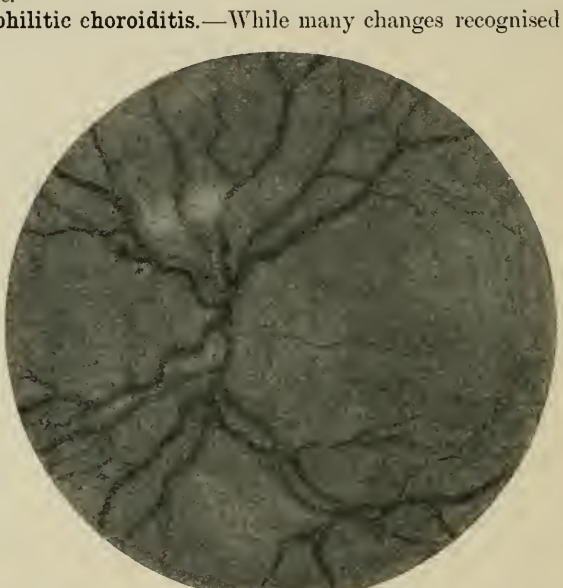


Fig. 140.—Diffuse acute choroiditis, showing hyperæmia of disc, vitreous haze, and superficial exudation.

the ophthalmoscope as choroidal are more or less directly the result of syphilis, there is one form of acute inflammation which, if not invariably a manifestation of syphilis, is so at all events in the vast majority of cases. It is a late secondary or early tertiary symptom of syphilis. In more than half the cases met with, traces of other secondary manifestations are found at the time of the outbreak of the choroidal inflammation. It is most frequent in elderly individuals, and appears altogether more likely to make its appearance in cases where syphilis is acquired late in life. Sometimes the choroiditis follows after a few

months on an attack of iritis. It is mostly met with in both eyes.

The *objective symptoms* are often very slight, namely, hyperæmia of the disc, with faint haze of the surrounding retina, and at the same time a fine diffuse opacity in the vitreous. The hazy appearance of the retina is partly due to the veiling by the opacity in the vitreous, which is always most dense in the central portion, and partly to serous exudation in the retina itself. It clears up to some extent as the eye remains in one

FIG. 141.—Choroiditis, with marked disturbance of retinal pigment in macular region.

position during the examination, owing to the sinking down of the vitreous opacities. In a number of cases the opacities are much more dense, and render the details of the fundus more or less indistinct. In all there is a great tendency for them to continue for a long time, or to disappear and reappear at intervals. In short, the constant association with more or less dense opacities of the vitreous is one of the characteristic symptoms of this disease.

Very characteristic also is a great difference in the acuity of vision, as well as in the form of the field of vision, found on

examination at one time in a feeble, at another in a strong, illumination. There is in fact often most marked night blindness. Thus one frequently finds that a patient who cannot read even large print when still sufficiently illuminated not to cause any perceptible diminution of acuity in the vision of the normal individual, is nevertheless able, when the illumination is strong, to read the very smallest print. He requires a more powerful light than is necessary under normal conditions to evoke the full functional activity of the retina. On the other hand,

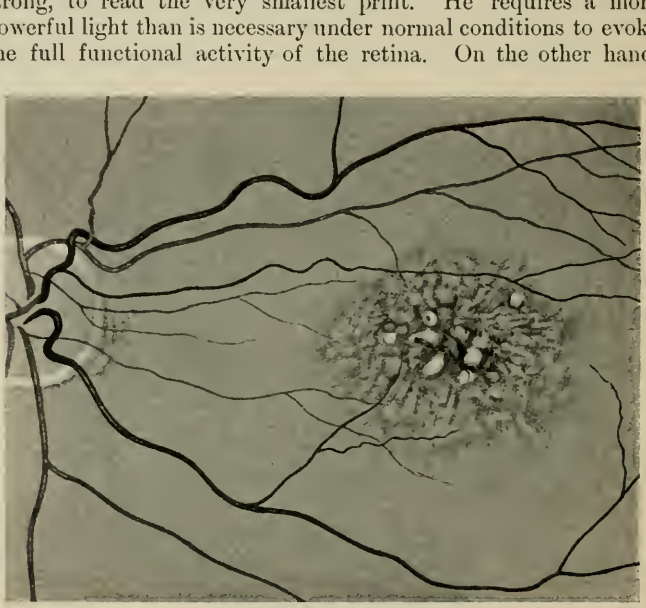


FIG. 142.—Showing a recent patch of central choroido-retinitis.—After FROST.

when the light is strong enough, the light-difference sense does not greatly differ from the normal.

Subjective sensations of light are often complained of, and are sometimes painfully persistent.

Metamorphopsia, and especially micropsia, is a very frequent symptom of acute syphilitic choroiditis. The micropsia is often extremely marked, and more so for objects held at some distance from the eyes. It is most apparent to the patient where the choroiditis exists in one eye only.

Acute syphilitic choroiditis may be recovered from without leaving any trace, and with perfect restoration of vision. Often

there may afterwards be seen, on careful examination of the more peripheral parts of the fundus, a number of yellowish spots, confined to that region. More frequently some defect of vision remains, due to the persistence of opacities in the vitreous and the gradual development of changes in the choroid, which have much the appearance of other forms of disseminated choroiditis. Occasionally very dense opacities remain, and these cases are usually associated with inflammatory changes in the iris, and ciliary body as well.

The best *treatment* is, no doubt, the mercurial, and preferably by inunction, continued as long as possible without giving rise

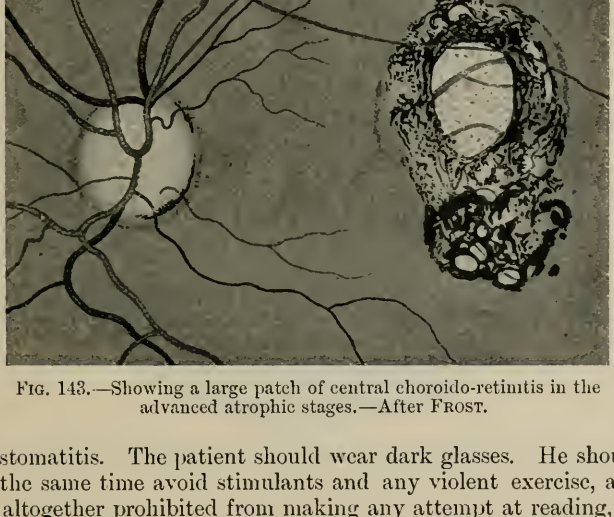


FIG. 143.—Showing a large patch of central choroido-retinitis in the advanced atrophic stages.—After FROST.

to stomatitis. The patient should wear dark glasses. He should at the same time avoid stimulants and any violent exercise, and be altogether prohibited from making any attempt at reading, or using his eyes for any work necessitating accommodation, or a strong illumination.

Posterior sclero-choroiditis.—*Staphyloma posticum.*—This is a slow, degenerative, inflammatory change of the choroid, with thinning of the corresponding portion of sclera, which takes place at the back of the eye. Staphyloma posticum is mostly found to the outer side of the papilla, but may extend all round it and involve the macula as well. The inflamed area yields to the intra-ocular pressure. In this way a true staphyloma

posticum is produced. The name staphyloma posticum is given, however, to very varying degrees of defect in the choroid in the immediate neighbourhood of the disc. The defect may be merely due to the aperture in the choroid at the site of the entrance of the optic nerve being larger than that in the sclera, whereby the scleral ring becomes broadened to the outer side, showing as a crescentic white patch, with its concave margin next the disc. Such a crescent may be met with along with all states of refraction, but is more frequently seen in myopic eyes.

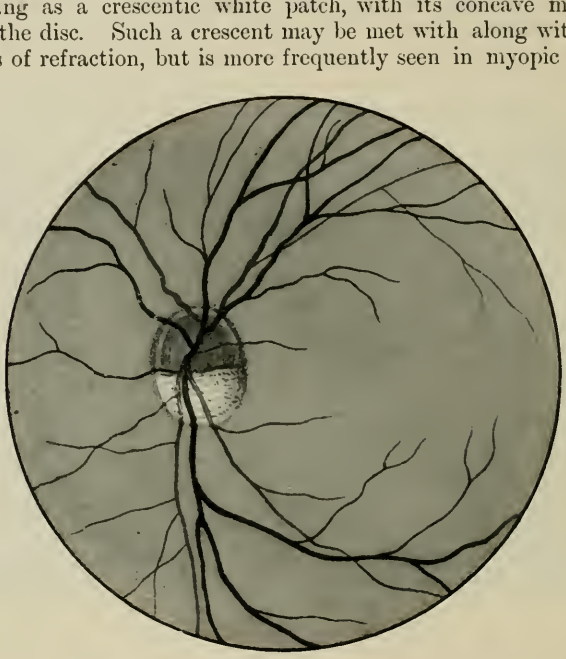


FIG. 144.—From a case showing atrophic crescent at lower portion of disc.

A very great enlargement of this patch may take place as the result of a slow form of sclero-choroiditis. This low inflammatory change only takes place in myopic eyes. A similar appearance, due to atrophic thinning of the choroid, is met with as a senile change.

As the area of degeneration extends in a myopic eye, it comes more and more to encircle the disc, though it is usually, even when very extensive, most marked to the outer side. In a small proportion of cases the crescent lies at the lower margin of the

disc. It is then congenital, and is associated always with some defect of visual acuity.

The white colour of the staphyloma posticum is due to reflection from the sclera below the patch of atrophy of the choroid and pigment layer of the retina. The superficial layers of the retina are not, as a rule, implicated in the process, and, as a consequence of this, the retinal vessels may be seen to course over it, just as in the cases of choroiditis elsewhere.

The margin of the staphyloma which is farthest away from

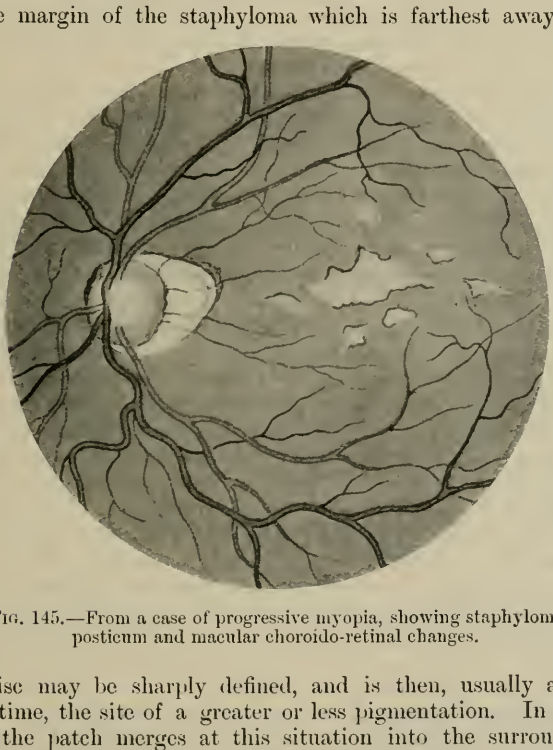


Fig. 145.—From a case of progressive myopia, showing staphyloma posticum and macular choroido-retinal changes.

the disc may be sharply defined, and is then, usually at the same time, the site of a greater or less pigmentation. In other cases the patch merges at this situation into the surrounding fundus without showing any very decided definition. Speaking generally, the first condition is an indication of an arrested, or only very slowly progressive, change, while the latter should give rise to more suspicion, as showing a greater likelihood of progression. In the very high degrees of staphyloma posticum the crescentic shape is altogether lost, and only a large white patch, sometimes with here and there some pigment spots, surround the

disc on all sides. These large areas of degeneration may even involve the macula. The protrusion, by increasing the antero-posterior diameter of the eye, causes axial myopia.

Posterior sclero-choroiditis, which causes the higher and progressive variety of myopia, often causes a dull aching pain. This pain, and the evidence of progression in the degree of the myopia, as well as the defect in vision which makes its appearance sooner or later, are the main symptoms of the disease being active. On the other hand, during a period of remission the vision does not alter in acuity nor the myopia in degree, while at the same time the pain is absent.

In connection with staphyloma posticum, and what must be looked upon as the immediate cause of the defect of vision in the progressive variety of myopia with which it is accompanied, are changes occurring in the region of the macula itself. These changes are rather different in their mode of origin from those characteristic of senile central choroiditis, which they may afterwards come to resemble pretty closely. They frequently begin as a kind of irregularity in the pigmentation at the macula, which takes the form of differently shaped figures darker than the surrounding fundus. Gradually the centres of these figures exhibit a yellowish or atrophic coloration, which encroaches more and more on the darkened area, and eventually becomes an atrophic plâque very similar to those met with in disseminated choroiditis.

Metamorphopsia is a constant symptom of this condition, and frequent complaints are made of muscæ, cloudy vision, and subjective light sensations. The symptoms, in short, all point to irritation of the retinal percipient elements.

The *treatment* is, on the whole, very unsatisfactory, especially where the condition has been going on for some time. Reading should certainly be avoided, and dark glasses be more or less constantly worn at times when the subjective symptoms point to activity in the inflammatory process and progression of the myopia. At the same time, it may be of use to leech or blister the temple.

Purulent choroiditis. — A purulent inflammation of the choroid, which may either remain confined to that membrane or lead to inflammation of all the tissues of the eye,—*panophthalmitis*,—occurs as the result of various lesions. Thus it may be set up by operations performed on the eye, or by penetrating wounds, with or without the lodging of foreign bodies within the eye. It may follow fresh perforations of the cornea, or any accident which causes a bursting or inflammation of a staphyloma of the cornea or sclera.

In a small but important group of cases the etiology is of an altogether different nature; in such the purulent choroiditis may result from thrombosis in the ophthalmic veins, from embolism in the choroidal arteries, or from septicæmia. The first class of cases may be grouped as cases of traumatic purulent choroiditis, the second as metastatic purulent choroiditis.

Traumatic purulent choroiditis.—The symptoms of purulent choroiditis are—very great pain in the eye, accompanied by rapid and complete loss of vision; redness and swelling of the lids; and chemosis. Swelling of the orbital tissues is also more or less marked, causing a tendency to protrusion of the eye, the mobility of which is at the same time interfered with, partly on account of the participation of the muscles and the mechanical difficulties which the presence of the exudation occasions, and partly, no doubt, owing to the pain alone. In cases which go on to panophthalmitis all these symptoms are more intense, and at the same time the cornea becomes more and more hazy from infiltration of leucocytes; the aqueous humour becomes muddy and purulent; and iritis, with hypopyon, makes its appearance. Purulent choroiditis always leads eventually to shrinking of the eye. This may follow rapidly on a spontaneous perforation of the coats, and the discharge of pus externally; or it may more slowly result from consolidation and partial absorption of the purulent matter, without perforation. In such cases, if the lens remain clear and the pupil is not occluded, the whitish mass of partially organised lymph may be visible.

In the *treatment* of purulent choroiditis we cannot expect to save the sight of the eye. All that can be done is to alleviate the excessive pain from which the patient suffers. For this purpose, when vision has been lost, an opening may be made in the eye to admit of the discharge of the pus.

Enucleation should not be performed at the time of the inflammation, owing to the risk that there is of thereby setting up meningitis.

The question as to whether enucleation should be done or not at a later period, when the eye has shrunk and the symptoms of active inflammation have subsided, is one which, as a general rule, may be left pretty much to the patient, as there is little danger of sympathetic inflammation occurring in the other eye. When purulent choroiditis seems to be threatened, it would appear that it sometimes can be kept off by the application of a tight bandage over the eye.

Metastatic purulent choroiditis.—By far the greatest number of cases in which a meningitis, from which the patient recovers,

is accompanied by purulent choroiditis, occur in very young children. Often such cases are first seen by the ophthalmic surgeon after the meningitis has subsided. The inflammation in the choroid leads to shrinking of the globe, rarely to panophthalmitis. And the appearance which the eye then presents is that which in this country is often called *pseudo-glioma*. The iris is then muddy, more or less atrophied, and pressed forward by the lens, so that the irregular pupil comes to lie close up to the clear cornea. The periphery of the iris is, however, in most cases retracted, sometimes markedly so. Through the lens, which usually remains clear, a white mass can be seen lying in the vitreous. The tension of the eye is diminished, and there is complete blindness.

It is seldom that any difficulty can arise in the differential diagnosis between this condition and true glioma, which also occurs in children; the retraction of the iris at the angle of the anterior chamber, and the diminished tension, are sufficiently characteristic symptoms.

Choroiditis following meningitis is probably due to direct transference of inflammatory products along the sheath of the optic nerve. One or both eyes may be affected, more frequently only one. There appears to be no danger of sympathetic inflammation of the other eye where one eye alone is affected, and therefore enucleation is not necessary. The evidences of the meningitis are not always equally marked. Sometimes there have been distinct convulsions, at other times only loss of appetite and drowsiness, with the history of sudden redness and swelling of the eye, and a yellow kind of glimmer from the interior. This appearance, with the chemosis and hypopyon, and the evident interference with vision, distinguish the cases from simple iritis.

Purulent choroiditis in one, sometimes in both eyes, leading to complete destruction of sight and to shrinking of the eye, either from perforation, or absorption and organisation of the deposit in the vitreous, may occur in pyæmia, puerperal fever, erysipelas, and ulcerative endocarditis, as well as in connection with inflammations, both idiopathic and traumatic, about the head or face. I have seen several cases occur in the course of an influenza. These have been due to a pneumococcus or streptococcus invasion. The immediate cause of the inflammation is probably not always the same; yet it is often, no doubt, as has actually been demonstrated, due to embolic infarcts in the choroidal vessels. There seems, too, to be a special disposition to marantic thrombosis, under the influence of sepsis,

in the finer vessels of the choroid, as it is almost solely in this region of the vascular supply from the carotids that metastasis is found. About one-third of the cases of metastatic choroiditis are bilateral. Ulcerative endocarditis has been found by Axenfeld to be present in one-half of all the cases of bilateral metastatic choroiditis occurring in different pyæmic conditions. The frequency of this association is not so great in unilateral cases. The worst cases of streptococcus invasion are therefore more likely to cause both the choroidal and the endocardial mischief.

In cases, again, of thrombosis of the cerebral sinuses, we may find a pretty sudden protrusion of the eye, with amblyopia or amaurosis, a dilated and motionless pupil, and more or less chemosis of the conjunctiva and œdema and redness of the lids. This may occur on both sides, but is most frequently found on one side only. Probably the thrombosis in the sinuses is not sufficient of itself to give rise to the choroiditis, but must be associated with thrombosis in the ophthalmic veins as well. Such cases always end fatally. The process may begin in the sinuses of the brain and spread to the ophthalmic vein, or it may result from a phlebitic process in the neighbourhood of some inflammation in the face, and spread back to the sinuses. In the first case there may often be great difficulty in diagnosing between the thrombosis of the sinuses and meningitis, as the cause of the panophthalmitis. When it occurs on both sides, more especially with an interval between the appearance of the inflammation in the two eyes, thrombosis would appear to be most likely. The state of the pupil may sometimes be of diagnostic importance in this respect:—in thrombosis it is generally dilated and motionless, while retaining its normal form; in choroiditis from meningitis, on the other hand, it may be irregular, and bound down by synechiæ.

Rupture of the choroid.—The choroid may be ruptured, partially or completely, by a blow on the eye with some blunt object, and with or without there being a rupture of the retina at the same time. The same injury may give rise to retroversion or separation of the iris, dislocation of the lens or other lesions in the anterior segment of the eye, but often the rupture of the choroid is the only change produced. The sclera immediately behind the ruptured choroid never gives away.

Ruptures of the choroid take place near the posterior part of the eye, and possibly at the anterior part, where they cannot be seen with the ophthalmoscope. They may be to either side of the optic nerve, or above or below it, and almost always coincide

roughly with segments of circles described round the papilla as a centre. Bifurcations may occur, and in some instances two or more distinct and concentric ruptures may take place.

The ophthalmoscopic appearances vary according to the completeness of the rupture and the length of time which has elapsed since the accident. If the eye is examined immediately after the injury, the rupture cannot, as a rule, be seen, but the retina is found to be swollen and hazy, and more or less veiled.

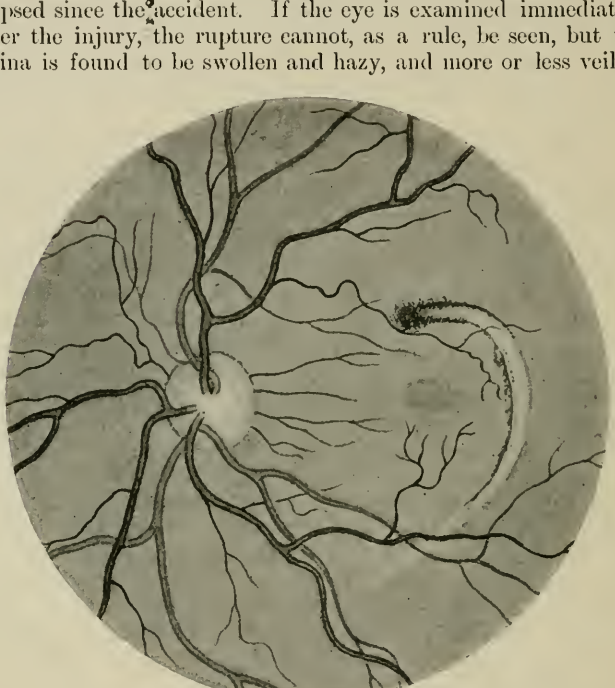


Fig. 146.—Rupture of choroid (inverted image).

In a few days this haziness in the retina disappears, and a sharply cut linear yellowish figure, concentric with the papilla, and over which the retinal vessels are seen to pass, makes its appearance not far from the papilla. This gradually becomes more and more white, and in the course of time is here and there pigmented. Pigmentary changes also often develop in other parts of the surrounding retina, particularly in the immediate vicinity of the optic disc. Rupture of the choroid generally causes very little bleeding, but the nature of the lesion

may remain for some time undetected owing to the bleeding from the iris, which has been injured at the same time.

The extent of the injury to vision differs very much in different cases, depending on the position and extent of the rupture. In large ruptures the vision is always permanently much reduced. Even small ruptures, if they take place immediately behind or close to the macula lutea, cause great interference with sight. In almost all cases the vision is much reduced immediately after the accident, and gradually improves

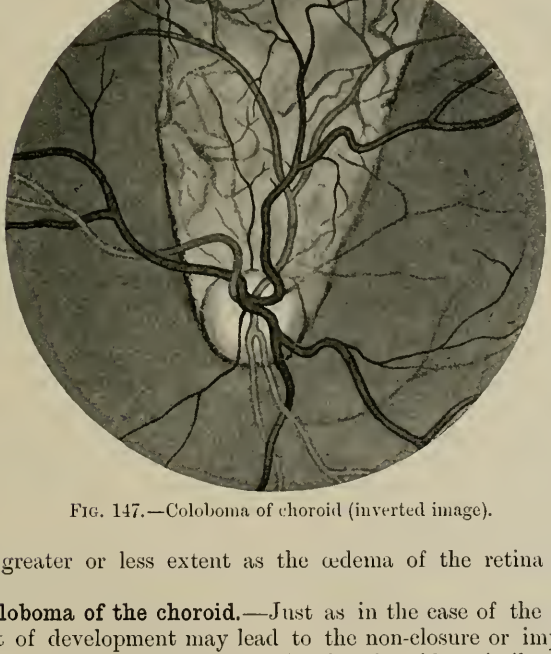


FIG. 147.—Coloboma of choroid (inverted image).

to a greater or less extent as the œdema of the retina passes off.

Coloboma of the choroid.—Just as in the case of the iris an arrest of development may lead to the non-closure or imperfect closure of the fœtal fissure, so in the choroid a similar defect may result from the same cause.

Coloboma of the choroid is most frequently associated with coloboma of the iris, but may be present alone, and be found in one or both eyes.

The true coloboma of the choroid is always met with downwards, or downwards and inwards. The defect is usually

narrower in the region of the papilla, which may or may not be included in it, and broader towards the periphery.

In all cases the retina is either completely absent, or only very imperfectly developed, in the region of the coloboma. There is therefore always a more or less complete scotoma, corresponding in extent to the coloboma.

On ophthalmoscopic examination a brilliantly white reflection is seen from the region in which the retina and choroid are defective. The surface of the coloboma is never of an equable colour throughout. Here and there, there are often to be seen masses of pigment. The white area, too, is often broken up by a number of different sized, very ill-defined, faintly bluish spots, corresponding to irregularities in the sclera, which is laid bare by the absence of the choroid, and the reflection from which causes the marked, almost dazzling, whiteness which is presented by the ophthalmoscopic picture of a coloboma of the choroid.

Vessels are also seen to course across the white area in different directions. These are both ciliary and retinal vessels. In many cases of coloboma only fine and narrow branches of the retinal vessels cross the coloboma, and in some there is an absence of retinal vessels altogether. This depends entirely, no doubt, on the degree to which the defect in development has involved the retinal structures which lie anterior to the pigment layer. When the disc is included in the coloboma, it may retain its normal appearance, but it is more often so altered as to be barely recognisable.

There is a rare form of coloboma in which the defect occupies the region of the macula alone. This is probably the result of degenerative inflammatory changes which have taken place in intra-uterine or infantile life. It may produce astonishingly little defect of vision.

Tubercle of the choroid.—Tubercle occurs in two forms in the choroid—as miliary tubercle and as larger tuberculous masses. The first form is acute, and always secondary to tubercle in other organs. The second is chronic, and may or may not be primary.

Chronic tuberculous choroiditis is certainly very rare—much more so than miliary tuberculosis. It occurs in one eye only, and appears sooner or later to be associated with similar disease of the brain, which ends fatally. The ophthalmoscopic changes in the cases which have been described have been those of optic neuritis (obliteration of the margin of the disc, great engorgement of veins, with sometimes hæmorrhages here and

there), and a diffuse white coloration over a large portion of the fundus.

From sarcoma it may be distinguished by the flatness of the swelling when compared with its superficial extent, by its more or less distinctly nodular form, and by the evident inflammatory changes in the surrounding choroid. It differs from purulent choroiditis in there being no history of injury, or any condition likely to set up that form of inflammation, as well as by its being relatively more circumscribed and localised to one portion of the choroid.

Miliary tubercle of the choroid is only met with in cases where there is already, or, much less frequently, where there is afterwards, an infiltration of the same nature in a number of other organs. It is probably never met with where tubercles exist in the lungs alone, and it appears to have no definite relation to tuberculous meningitis. In fact it is if anything least common in children in whom tuberculous meningitis is most common. As the tubercles are late of appearing in the choroid, or at all events of becoming visible on ophthalmoscopic examination, it is seldom that the diagnosis of general tuberculosis is facilitated by the use of the ophthalmoscope. When present, they afford a positive proof of the tuberculous nature of the general disease, while their absence does not exclude the possibility of it. It appears certain that choroidal tubercles occur at some time or other in by far the greatest proportion of all cases of miliary tuberculosis.

A considerably larger number of tubercles is always found on post-mortem examinations than can be seen with the ophthalmoscope. This is due partly to some being located in that part of the choroid which cannot be seen, but mainly to their not all having advanced so far as to destroy the pigment layer in front of them. When making their appearance, as they often do, only a few days or hours before death, the state of the patient may be such as to render an ophthalmoscopic examination difficult.

Miliary tubercles generally occur in both eyes, sometimes only in one, and always in the choroid—never in the retina. They are always round, and vary in size from one-sixth the diameter of the papilla, or less, to quite half as big again as the papilla. Usually the size in any particular case is from one-third to two-thirds the diameter of the papilla. The larger ones are distinctly prominent. Their colour is very distinctive, and makes it all but impossible to confound them with any other form of patch characteristic of the numerous varieties of dis-

seminated choroiditis. There is a regular transition from the normal red colour of the fundus at their margins to a dull yellowish-white at their centre.

Hæmorrhages in the choroid.—Hæmorrhages are hardly of such frequent occurrence in the choroid as in the retina. The smaller choroidal hæmorrhages may usually be distinguished from the retinal ones by their not having any constant relation to retinal vessels, and not presenting the flame-shaped appearance which characterises retinal hæmorrhages in the nerve fibre layer. When near the retinal vessels, these vessels may sometimes be seen to pass over them. Large choroidal hæmorrhages, again, are not bordered by such a sharp and regular line as is the case in large retinal extravasations. It is impossible, however, with certainty to diagnose the position of a hæmorrhage, as those originating in the deep layers of the retina, when of moderate size, exactly resemble hæmorrhages in the choroid. There is more tendency, possibly owing to the resistance offered by the lamina vitrea, for a choroidal hæmorrhage to pass backwards than into the retina. When large, the choroid may be detached by the accumulation of blood between it and the sclera.

Choroidal hæmorrhage may be of traumatic or idiopathic origin, and, according to its extent and the position of the extravasation, may interfere greatly or not at all with sight. On absorption it leaves an atrophic patch, bordered with pigment.

Ossification of the choroid.—In eyes which have been lost by irido-cyclitis, accompanied by an exudative choroiditis, true bone may in the course of time be found in the choroid. The plate of bone formed takes the shape of the inner surface of the eye. The formation always ceases at the border of the ciliary body, in which ossification never takes place. I have also always seen an aperture left at the position of entrance of the optic nerve.

As the eyes in which ossification takes place are otherwise destroyed, the *diagnosis* can only be made by feeling a hard body, which ends sharply some 4 or 5 mm. from the corneo-sclera margin.

The presence of bone in the choroid is usually associated with irritation and pain, but it is not liable to give rise to sympathetic inflammation. The *treatment* should be enucleation.

Diseases of the Vitreous.

Acute purulent inflammation of the vitreous may occur when a foreign body is lodged in it, or it may be the result of the

extension of some inflammation from other parts of the eye. When once it is set up, the eye is doomed, and eventually shrinks. This result may or may not be preceded by perforation, with evacuation of more or less pus. Less severe inflammatory conditions of the vitreous probably never occur primarily, but are always associated with inflammation of the ciliary body, choroid, or retina. Clinically, however, the condition of the vitreous is often the point of primary importance, as the passage of inflammatory exudation into its substance gives rise to opacities, on the existence of which the defect of vision accompanying the particular inflammation may mainly or entirely depend. This is, for instance, the case in cyclitis, and to some extent also in syphilitic choroiditis.

Opacities of the vitreous may be stationary or floating. They may be diffuse and punctiform, filamentous, flaky, or membranous. These opacities are mainly of two kinds, either due, as has already been said, to products of inflammatory exudation from the vascular membranes of the eye, or to the effusion of blood from the vessels of these membranes. As the result of exudation into the vitreous, the gelatinous consistency which it normally presents may become altered. The vitreous may thus become abnormally liquid or abnormally condensed and shrunken.

Liquefaction of the vitreous, or *synchisis*, may be diagnosed with certainty when that body contains more or less organised opacities which alter their position with great rapidity with the movements of the eye. All cases of liquefaction of the vitreous are not accompanied by floating opacities.

The diagnosis of liquefaction without opacity may be extremely difficult. The cause of such cases, too, is often very far from being apparent. Condensation of the vitreous, on the other hand, may generally be inferred when, along with more or less diffuse and stationary opacity, there is considerable diminution in the tension of the eye. This condition is likely sooner or later to be complicated by detachment of the retina.

Diffuse opacity of the vitreous is a most constant accompaniment of syphilitic choroiditis. This causes, as a rule, greater visual disturbance than circumscribed floating opacities, the patient complaining of a cloudiness over the objects seen, and often at the same time describing this veiled appearance as swaying to and fro. Such diffuse opacities frequently partly clear away, and then reappear several times during the course of the disease. They usually last for months, and eventually, as a rule, entirely disappear.

Exudations or effusions sometimes coagulate into filamentous or thread-like opacities, which, when freely movable, are projected by the patient as snake-like black objects, which are continually changing their shape and position. Membranous opacities are either free, and capable of assuming, as they fold or

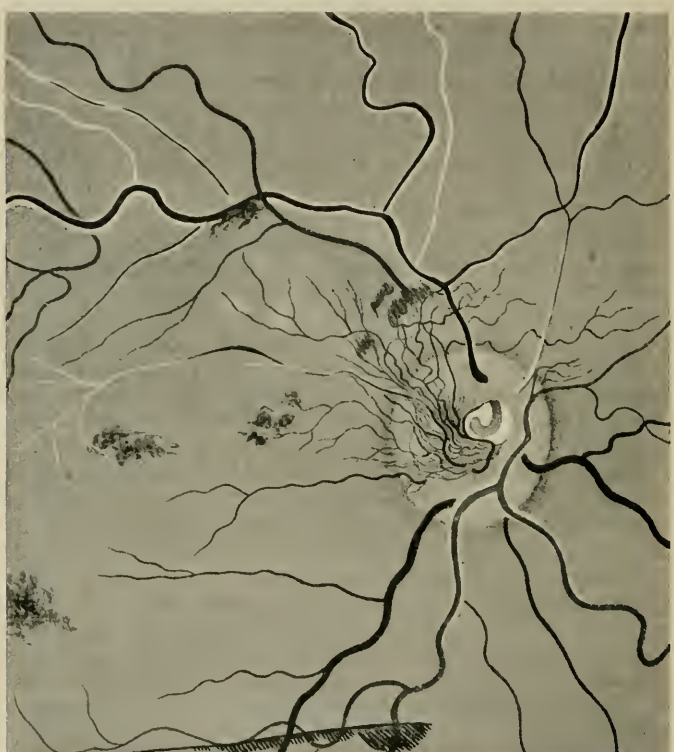


Fig. 148.—Showing formation of fine blood vessels in vitreous.—After Frost.

unfold, numberless forms; or they are fixed to the papilla or retina, and only sway about at their free ends. Sometimes these fixed membranes contain newly formed blood vessels, but the vascularisation of vitreous opacities is rare.

Bleeding into the vitreous takes place owing to the giving way of some vessel or vessels in the retina, choroid, or ciliary

processes. This may be the result of a trauma, or be due to a diseased state of the vessels or of the blood. When the patient observes the pretty sudden defect of vision which such a bleeding may occasion, the cloud or veil which comes in front of his sight often appears at the same time of a distinctly red colour. When the extravasation is very large, the blindness produced is pretty complete. Most commonly, however, only a portion of the vitreous is infiltrated with blood, and as this gradually gravitates to the most dependent part, the cloud is generally thickest in the upper portion of the field of vision. Great differences are observed in the rate of absorption of the blood, differences which depend partly upon the age of the patient, and partly, no doubt, also upon the state of the choroid and retina. Often a particularly slow absorption is really due to the recurrence every now and then of hæmorrhages before a previous extravasation has properly cleared away. The absorption may be complete, or may leave flaky or irregularly shaped opacities, which alter their position with the movements of the eye with more or less rapidity, according to the consistency of the vitreous. These masses are projected as black spots or patches, which appear to be constantly in motion when the eye is moved, and to fly or move slowly upwards when it has come to rest.

When the normal consistency of the vitreous has not been much interfered with, the blood clot may keep pretty much in the line of sight, and thus greatly interfere with vision; or the patient may learn, by making a sudden movement of the eye, to get rid of the dense cloud for a few seconds, and thus be able to read; but he has constantly to repeat this movement, and is only able to make out a few words, it may be, at a time. This symptom of only being able to read a few words at a time without suddenly altering the direction of fixation is quite characteristic of a large blood clot in the vitreous.

To ophthalmoscopic examination the blood lying in the vitreous appears red if fresh, and black if some time has elapsed since the extravasation took place. Often the red reflex from the surface of the blood clot may be made out by oblique illumination, if the eye be brought as nearly as possible in a line with the convex lens. It appears to be more commonly the choroid than the retina from which extravasations of blood take place into the vitreous. At all events, subsequent changes are most frequently found in that coat.

A somewhat rare but distinct clinical type of disease is the occurrence of repeated hæmorrhage into the vitreous in young

individuals. It seems to result from periodic capillary hyperæmia of the choroid. It is most common in young men of effeminate, as distinguished from active or energetic, temperament.

In some cases recovery is eventually complete, though when there have been repeated attacks this is not generally the case. It appears possible that some may proceed to the formation of connective tissue bands on the retina, and thus be the beginning of retinitis proliferans.

A peculiar form of vitreous opacity, which gives rise to a very beautiful ophthalmoscopic appearance, is that caused by the accumulation of cholesterine and other crystals in the vitreous. As at the same time the vitreous is liquid, this condition has received the name of *synchisis scintillans*, from the glistening caused by the reflection of light from the surfaces of the crystals. On ophthalmoscopic examination the glittering spots, which have much the appearance of small particles of gold suspended in a liquid, are seen to dance about with the slightest movement of the eye.

The condition is one met with almost exclusively in old people. When found in younger eyes it is usually, if not invariably, secondary to some serious alterations which have very much impaired the sight. It often remains stationary for years, and does not admit of, or indeed call for, any treatment.

The *prognosis* in cases of vitreous opacity depends on the extent to which the organisation of the opacities has gone. When the eye is otherwise healthy, even opacities which have lasted for several months may eventually disappear. When the vitreous is very liquid,—especially if, at the same time, there are extensive choroidal changes,—the condition is not likely to improve.

The *treatment* has mainly to be directed against the cause of the opacities, so far as that can be discovered. Such methods of promoting absorption as pilocarpine injections, wet packing, etc., should be tried.

Persistent hyaloid artery.—In the embryo an artery passes from the central artery of the retina to the back of the lens, where it divides into a network of vessels destined for the nourishment of the lens. This disappears altogether before the end of fœtal life, but the transparent sheath by which it is surrounded persists, and forms the so-called central canal. Very rarely more or less pronounced rudiments of the artery remain. In such cases an opaque, usually somewhat tortuous, cord can be seen with the ophthalmoscope to stretch from the centre of

the papilla forwards to the back of the lens. Sometimes there is at the same time some other persistence of a fœtal structure, such as remains of the pupillary membrane, etc., and the vision is generally not of normal acuity.

Cysticercus in the vitreous.—The presence of a cysticercus in the eye is altogether an extremely rare occurrence in this country. Its development takes place between the retina and the choroid, and gives rise to detachment of the retina. At this stage it is almost always possible from the colour and shape to diagnose the cause of the detachment. Later on, perforation of the retina takes place, and the parasite passes into the vitreous.

The *treatment* consists in attempting to remove the cysticercus. Such operations have been frequently performed, and with very great success. Vision is not always preserved, but in most cases, at all events, the eye comes to rest without shrinking, and without the necessity for enucleation. The best chances are presented by cases in which the vesicle is still subretinal. The success of an operation depends greatly on the correctness with which the position occupied by the cysticercus can be localised.

CHAPTER XI.

FOREIGN BODIES IN THE EYE.

Foreign bodies in the anterior chamber.—A foreign body may enter the anterior chamber by passing directly through the cornea; or it may reach this position after penetrating through the iris or lens, entering the eye through the sclera. The wound in the cornea is generally in its lower half, as the upper is mostly covered by the lid, but it sometimes happens that the lid is perforated before the cornea. In that case, however, the force of propulsion mostly carries the body deeper into the eye, lodging it in the vitreous, or choroid, or sclera, or even in the orbit beyond.

A foreign body in the anterior chamber may cause more or less severe inflammation of the iris and adjacent parts, leading in the worst cases, if it is not removed, to eventual destruction of the eye. The inflammation, on the other hand, after continuing for some time may subside, and the foreign body become encapsuled. In some cases it happens that the foreign body lies free in the anterior chamber, without producing any irritation, or it may become absorbed, with or without at the same time setting up inflammatory reaction. The first result is by far the more common. It occasionally happens that the inflammation produced is limited to the anterior portion of the eye, and this may eventually lead to perforation, and expulsion of the foreign body through the cornea. More frequently, however, the presence of the foreign body causes either slow insidious irido-cyclitis of the worst type, or more active purulent irido-choroiditis, which is followed by phthisis bulbi. Encapsuling is very rare, but it not so infrequently happens that no irritation is produced at all; and this result is most common when the foreign body is a piece of coal or carbon, or of some chemically inactive metal.

No doubt the effect produced will depend in great measure upon whether or not septic matter has been introduced into the

eye at the same time. It is not easy in any given case to make sure of this point; but as a general rule hot pieces of metal are aseptic, and accidents with such pieces admit of a better prognosis from the first. Something depends on the nature of the metal itself. Copper, for instance, even if aseptic, gives rise to much more irritation than steel or iron.

Foreign bodies in the iris.—The iris is on the whole a rather uncommon site for a foreign body within the eye, as the force which propels it so far is mostly sufficient to carry it farther. The presence of a foreign body in the iris is likely to lead to much the same results as those just described when it lies in the anterior chamber. Absorption is less likely, and encapsuling more likely.

The first effect which a foreign body produces in the iris is to give rise to hæmorrhage, which in most cases is so slight as to already have become absorbed, or to have left but faint traces, by the time the case comes under observation. Most frequently this is followed by iritis, the symptoms of which do not become prominent until a day or two after the accident. According to the size and nature of the foreign body, and the presence or absence of micro-organisms, the iritis, which its presence produces, may be purulent, or merely plastic. In the first case, the complete destruction of the eye takes place rapidly by panophthalmitis; in the second, the foreign body may become encapsuled, or inflammation may uninterruptedly, or by recurrent attacks, cause loss of vision in the way commonly met with in cases of old-standing iritis.

Foreign bodies in the posterior aqueous chamber.—Foreign bodies usually lodge in the posterior aqueous chamber by penetrating the eye slantingly, at or near the cornea-scleral junction. Sometimes the external wound is found to be in the central portion of the cornea. A foreign body in this position almost invariably, and especially if it be of any size, sets up inflammation in the iris and ciliary body, and often gives rise at the same time to cataract.

The diagnosis of foreign bodies in the aqueous chambers and iris.—The history of the accident must be carefully inquired into. If it turns out that the eye has been forcibly struck by a small body, there is the possibility or probability that it has penetrated it and remained in the eye. The cornea should then be examined by oblique illumination for any appearance of a scar. If none be found on the cornea, the sclera should also be examined, but the absence of any visible cicatrix there is not conclusive evidence against the previous existence of a wound.

Fortunately for the diagnosis, the wound produced by a foreign body lying in the anterior section of the eye is found to be at least nine times out of ten in the cornea.

When a fresh wound or scar is discovered in the cornea, the question arises, has or has there not been perforation? To determine this we must observe—the shape of the pupil, the depth and contents of the anterior chamber, the condition of the iris and lens, and the tension of the eye. We must also notice whether any synechiæ, anterior or posterior, have formed, or whether there is any prolapse of iris or vitreous, or any trace of uveal pigment in the corneal wound. It is only in the case of relatively large foreign bodies that the tension is reduced or the chamber shallowed, unless the patient happens to be seen immediately after the accident, when the diagnosis of the perforation is easier. Any prolapse is of course a certain evidence of perforation, while wounds of the iris or lens, hyphæma, hypopyon, and synechiæ, point more or less conclusively to the same.

When taken along with the history of the accident having been caused by a small body, any or several of these evidences of perforation render it extremely probable that a foreign body is lodged in the eye, and the next point is to determine where. In the first place, is it in the anterior or posterior section? The most important aid towards the solution of this point is afforded by the examination of the vision and field of vision. In all cases where the anterior portion of the eye is the site of the foreign body, the vision corresponds to the visible optical changes, whereas this is not the case where the posterior portion of the eye is that into which it has penetrated. If it be in the posterior aqueous chamber, the diagnosis is always difficult, as it is always hidden by the iris, unless, as sometimes happens, a portion of it may be sticking out beyond the pupillary margin, where it may be seen, if the aqueous and cornea be clear. When in this position, it often happens, too, that the iris has been penetrated, and the diagnosis thus facilitated. The presence of a foreign body in the posterior chamber, if it is not very small, is always indicated by a protrusion of the iris over it, or by a drawing up of the pupil towards the spot. Sometimes these appearances are so slight as to make the supposed cause very uncertain, and indeed, it occasionally happens that the diagnosis of the presence of a foreign body in this position is impossible.

Although the anterior chamber and iris are freely exposed to view, the existence of a foreign body in either position is not always easily diagnosed. When in the anterior chamber, it may

have sunk down into the angle, and, if small, be difficult of detection; or the cornea may be hazy at its periphery, or the chamber occupied by more or less pus or blood. When of any size, if the cornea is clear, and there is no hyphæma or hypopyon, the body can generally be seen, either, in fresh cases, in its natural state, or, in cases where some time has elapsed since the accident, surrounded by lymph, appearing then usually as a sharply defined yellowish mass. When not thus directly visible, the points which nevertheless render the diagnosis of its presence more or less certain, are a localised circumcorneal injection, and tenderness to pressure, with some retraction of the pupil in a particular direction, usually downwards, where the foreign body commonly lies. Apart from this, the existence of inflammatory reaction, the severity of which would be greatly out of proportion to the trauma if no foreign element existed in the eye, is of very considerable diagnostic importance.

If in the iris, a foreign body can generally be seen, though, if small, some care is necessary in the examination, and a doubt may sometimes exist as to whether a particular appearance is actually caused by the presence of a foreign body, or is merely a pigment spot. Sometimes, when the iris is prolapsed, the foreign body is found in the prolapsed portion.

Treatment.—Very small portions of iron or steel, if they have caused little irritation, may be left, on the chance of absorption taking place in the course of time, but the patient should be kept constantly under observation, so that the first symptoms of irritation, should they afterwards arise, may be noticed, and an attempt be made to remove the body. In all cases of iron or steel, the simplest method of removal is with the electro-magnet. The incision necessary for their removal should be in the corneo-scleral margin, and, except when the piece of metal is sticking in the iris, it should be made at the lower part of the cornea. The size of the incision must be regulated according to the size of the foreign body to be removed, and should always be bigger than it is, so as to prevent its being rubbed off as the magnetised probe is withdrawn. Portions of the non-magnetisable metals or other substances have to be removed with a curette, or pair of *ribbed* (not toothed) forceps. In the case of small bodies lying in the iris, the curette is usually the simplest; for larger objects, especially when they lie free in the anterior chamber, the forceps are preferable.

In any case, the wound at the corneo-scleral margin must be made of sufficient size. Should it be found, after the foreign body has been seized, that it cannot be withdrawn, and some-

times it turns out bigger than it appeared to be, the operator must *not* let go his hold of it, but proceed as best he can to enlarge the wound until it admits of its removal. Where any doubt exists in the diagnosis, a paracentesis, made with antiseptic precautions, so as to admit of the escape of the liquid contents of the anterior chamber should be undertaken.

In the case of foreign bodies embedded in the iris, it is usually necessary to excise the portion of iris in which they lie as well, but an attempt may be made in the first place to remove the foreign body alone. If this can be done without much laceration, the iris may be left; if not, it should be excised.

Foreign bodies in the posterior chamber are usually difficult to extract; it is almost invariably necessary to remove a portion of iris as well—sometimes the lens has also to be extracted. The best plan is to attempt to seize the foreign body through the iris, and cut off all that is withdrawn through the opening made for the removal. When the iris is prolapsed in an accident which renders the lodging of a foreign body in the eye possible, it should be carefully examined and bathed with an antiseptic lotion before being returned into the eye. If it is much bruised, or some time has elapsed since the accident, it is better to cut off the prolapsed portion.

All operations performed for the removal of foreign bodies require great steadiness on the part of the patient, and, unless this can be ensured, should not be undertaken without an anæsthetic. For such cases, in children at all events, cocaine is insufficient. How soon and how completely the irritation produced by the presence of the foreign body will subside, depends greatly on its size and nature, and the length of time it has remained in the eye. The possibility of sympathetic inflammation of the other eye has always to be taken into consideration in the treatment.

Foreign bodies in the lens.—When a foreign body enters the eye at all, it is perhaps on the whole most fortunate for the patient if it happen to lodge in the lens. Little or no inflammatory reaction follows, and there is, practically speaking, no chance of sympathetic ophthalmitis. Inflammation may arise owing to the wounds produced by the perforation of other superjacent structures, principally the iris and ciliary body.

A small foreign body passing through the centre of the cornea, and lodging in the lens without traversing the iris, may produce so little irritation or disturbance as to leave the patient ignorant of having sustained so severe an injury, until the vision becomes

gradually more and more impaired by the advancing opacity of the lens. A foreign body in the lens, in fact, almost invariably causes cataract. In rare instances only a limited opacity surrounding the foreign body results, as, for instance, in the case of small particles of gunpowder. Great differences are met with in the rapidity with which the cataractous change advances—differences depending on the size of the opening in the capsule, and the length of time which it remains open, as well as on the age of the patient. Small capsular wounds, caused by small bodies, heal of themselves; larger ones are often plastered over by the overlying iris.

A lens which becomes cataractous by lodging a foreign body is eventually partially, and in some rare instances completely or almost completely, absorbed, and the foreign body may, after a longer or shorter period, become displaced into such a position as to give rise to serious inflammatory disturbance. More or less irritation is always caused when the capsular wound is sufficiently large to allow of the escape of lens matter into the anterior chamber. Swelling of the lens within its capsule is liable at the same time to take place. These accidents are better tolerated in the young than in older individuals.

Only very rarely do small foreign bodies lodge in the lens capsule. They cause neither much irritation nor cataract, only a slight opacity in the capsule itself.

Diagnosis.—When penetration has taken place through the sclera, the chances of the foreign body being in the lens are very small, but it may have passed in obliquely, either through the ciliary body or from the posterior aqueous chamber. When evidence of a perforating wound has been found in the cornea, with the history of a small particle of metal or other substance having been propelled against the eye, and yet no appearance of a foreign body in the aqueous chamber or iris, the capsule of the lens should be carefully examined by oblique illumination, and with the pupil well dilated by atropine. In difficult cases examination of the capsule is preferably made with the ophthalmoscope, by reflecting light into the eye, and bringing a strong convex lens in front of the aperture. In this way the wound or scar in the capsule will almost always be detected. When this is discovered, it is certain that the foreign body has entered the lens, and the point remaining to be determined is, whether it has passed through it or lodged within it.

The diagnostic evidence in this respect is either positive or negative. In the first place, in a good many cases it may actually be seen on oblique illumination or on examination with

the ophthalmoscope, in the manner described. If metal, it then presents a glistening appearance. Sometimes, though the foreign body may not be directly visible, an area of greater saturation may be made out in one particular part of the lens, occasionally with a distinct streak of opacity running up to it. This portion, or it may be the whole lens, may at the same time exhibit more or less coloration, produced by oxidation or otherwise. The negative symptoms of importance have mainly to be relied on when the whole lens has become opaque. But even where there is considerable transparency, the diagnosis will be strengthened by finding no evidence, on ophthalmoscopic examination, of the presence of any body in the deeper parts of the eye. The negative evidence in favour of the lens being the site of the foreign body known to have entered the eye consists, in the first place, in a disproportion between the lesion and the irritation set up by it, and also in the absence of positive movable scotomata or of restrictions in the field of vision, such as are indicative of the presence of foreign bodies in the vitreous.

The *treatment* will depend on the degree of opacity to which the foreign body has given rise. In most cases it is inadvisable to perform any operation until complete cataract has resulted. The exceptions to this are cases where a glaucomatous condition is set up by the swelling of the lens in its capsule, and in which, therefore, immediate extraction is indicated. In other cases, too, in which the opacity in the lens is incomplete and practically stationary, operative interference seems sometimes justified before a spontaneous ripeness has been arrived at.

It is rarely advisable, in any case where a foreign body is lodged in the lens, to attempt any operation but the removal of the cataract through a large section. When the body is a magnetisable metal, this may be done in the ordinary way by first rupturing the capsule with a cystotome. The piece of metal then usually comes out along with the cataractous lens; but, should it remain behind, it is generally possible to extract it with the electro-magnet, which should always be at hand when such operations are undertaken. In cases where the piece of steel or iron is seen lying immediately behind the capsule, the magnet should be used before completing the extraction. In the case of non-magnetisable substances, although they may often in the same way be removed along with the cataract, it is safer on the whole to extract the lens in its capsule, if the case admits otherwise of the performance of this operation.

Foreign bodies in the posterior section of the eye.—Considerably the largest proportion of cases of foreign bodies in the

eye are those in which the body has penetrated into the deeper structures. This is unfortunate, because of the uncertainty of our being able to remove the foreign body, and because of the tendency to sympathetic inflammation.

Large portions of metal always produce so much destruction by their mere presence, that the case may be hopeless from the first, while in all but a very few cases the chances of operative interference being successful will depend almost entirely on whether the patient is seen soon after the accident or not.

As in the case of foreign bodies lodging in the anterior portions of the eye, those which are found in the vitreous and posterior coats pass into the eye most frequently through the cornea, wounding the iris and lens, or the lens alone, on their way. Some, and more particularly shot pellets, may first traverse the sclera and then enter the vitreous chamber. A body propelled in this way through the sclera may, according to the inertia it has, be arrested in the coats of the eye, at the same side of and near the aperture of its entrance, or it may drop into the vitreous, lodge in the coats of the eye at the opposite side, or penetrate these and come to rest in the tissues of the orbit. This last occurrence is not so very uncommon in the case of gunshot injuries. If the foreign body does not remain permanently fixed in the coats of the eye at either side, it sinks sooner or later in the vitreous, and then only alters its position owing to contractions which may take place in the exudation surrounding it.

The first effect produced, as a rule, by a foreign body entering the back portion of the eye is to cause hæmorrhage from the choroidal vessels. The blood usually accumulates at the anterior part of the vitreous, in which position it may often be made out with the ophthalmoscope. When it lies farther back, it is suggestive of rupture having taken place near the posterior pole of the eye. When much blood is extravasated, it is not long in sinking to the bottom of the vitreous chamber. The vitreous then generally becomes more or less infiltrated with pus, and this infiltration may be accompanied either by violent inflammatory symptoms, panophthalmitis, or these symptoms may be less severe, but eventually also lead to shrinking of the globe. If the course of the case be carefully watched from day to day, the first symptoms of a purulent inflammation are often observed to be linear, in the form of a streak which indicates the passage taken by the foreign body through the vitreous. Not infrequently this streak leads to a place where the infiltration is denser, and it is within this denser portion that the foreign body lies. Occasionally a foreign body, after setting up some irrita-

tion, becomes encapsuled in the vitreous; but although the eye then comes to rest, there is always the danger of recurrent attacks of inflammation, and ultimate destruction. It should always be remembered that a fresh attack of inflammation, even after there has been a quiescence of years' duration, may give rise to sympathetic ophthalmitis. In cases left to themselves, the greatest security against sympathetic inflammation is afforded by panophthalmitis, particularly if this should happen to lead to the spontaneous expulsion of the foreign body. A protracted or even permanent quiescence is most likely to follow when the foreign body is a shot pellet, for which the prognosis is more favourable than for most other bodies in the vitreous.

The result is more favourable when the foreign body, whatever its nature, is situated in the ocular wall. Most frequently it becomes embedded on the same side as that by which it enters the eye, the force of propulsion not being sufficient to carry it into the vitreous. In this position it may cause comparatively little irritation, though more frequently slow inflammatory changes are induced, leading to loss of vision and phthisis bulbi. A localised ulcer may form, and the foreign body be spontaneously expelled. When the site occupied is the ciliary body, cyclitis is set up, and vision is greatly reduced by opacities in the anterior part of the vitreous, followed often by cataract, or by more serious changes. When the foreign body becomes lodged in the opposite wall of the eye, which is considerably more uncommon, the chances of its being encapsuled, and good, or relatively good, sight being retained, seem to be rather greater, though the eye can never, even under the most favourable circumstances, be looked upon as absolutely safe. Inflammation may be set up after long intervals of time. Much depends in the first instance, no doubt, upon whether or not septic matter is introduced into the eye at the same time. The prognosis is relatively good in the case of shot pellets and small pieces of clean steel or iron.

Diagnosis of foreign bodies in the vitreous and posterior coats of the eye.—The history to be obtained in cases where there appears reason to suspect that a foreign body is lodged somewhere in the back part of the eye is often very unsatisfactory, especially if some time has elapsed since the accident. With an uncertain history, and the absence of any external scar, the diagnosis is often a matter of no little difficulty. The preponderance of cases where the eye is pierced through the cornea is only about half as great as in the case of foreign bodies in the anterior chamber or iris. It may be taken roughly that in four

out of every five cases the cornea is wounded, instead of nine out of ten. When a corneal wound or scar is found, the diagnosis is of course more easy. Further evidences of perforation are then looked for in the iris and lens. The vitreous must next be explored with the ophthalmoscope. Owing to the great magnifying power of the eye, it may be possible to see even very small foreign bodies in this situation if the opacities in the lens and vitreous are not too great. By causing the patient to look well down, it will not seldom be found lying at the bottom of the vitreous chamber, and when metallic, will be seen to glisten with a whitish or bluish-white lustre.

There is just the possibility of mistaking air bubbles, which are sometimes found in the vitreous after an accident, for portions of metal. Air bubbles are round, often multiple, and glisten at the centre, while they appear dull and obscure at their margins. The glistening from a portion of metal is from its margin, the rest presenting a bluish or greenish white coloration. When the external wound has been in the sclera, it is often not easily discovered, even when fresh, owing to surrounding hæmorrhage or inflammatory hyperæmia. A recent scar may be detected on oblique illumination, and perforation may be inferred when the superficial tissues are tacked down to the deeper, and not freely movable over them. In fresh scleral wounds the probe may be used carefully if doubt exists as to perforation.

If the patient cannot furnish satisfactory information with regard to the body by which the eye has been injured, he may possibly remember whether the vision was much affected at the time of the accident or not. Obscuration lasting some days is suggestive of there having been hæmorrhage, more especially if followed by black objects floating in front of the eye; but this is of course not conclusive evidence that anything remains in the eye. When the foreign body, or the yellowish mass of lymph by which it is surrounded, is visible by means of the ophthalmoscope, we may sometimes obtain positive evidence of its being steel or iron by observing a change of position of the whole mass on bringing a powerful magnet in contact with the eye.

The diagnosis of the position of the foreign body when seen by the ophthalmoscope is easily made. When it is lodged in the coats of the eye, we find that the same lens is required for accurate focussing of it as for focussing the rest of the fundus, and that there is only very slight or no parallax. Most frequently in such cases there is some evidence of disturbance in the coats surrounding the foreign body—often a whitish patch,

bordered with pigment, where the choroid has been ruptured at the time of its lodging in the eye.

It is only rarely that the glistening of a choroidal plâque may give rise to an appearance so like that of a piece of metal in the eye, that some difficulty may be experienced in making a correct diagnosis. A piece of metal rarely if ever glistens all over, but mainly at its margins, whereas the glistening from a choroidal plâque is not limited to any particular point, and in fact is often all over.

When the foreign body cannot be directly seen, but the history and objective appearances of perforation point to its being present in the eye, a tenderness on pressure at some particular point over the sclera indicates its position in not a few cases. A point, too, of diagnostic importance in a doubtful case is the existence of an amount of inflammation disproportionate to the severity of the trauma alone. This should always give rise to the suspicion that something is lodged in the eye.

Attention must also be paid to the nature of the visual disturbances. Apart from the defects corresponding to the visible optical changes which alone exist in the case of bodies lodged in the anterior part of the eye, there may usually be made out other defects as well when the vitreous chamber or coats at the back of the eye are the site of the foreign body. These are of two kinds, positive scotomata and restrictions in the field of vision. The scotoma may be either the projection externally of the shadow thrown on the retina by the foreign body, or it may be due to a lesion in the fundus of the eye. Restriction in the field of vision is due either to the presence of blood or purulent exudation in the vitreous, or to detachment of the retina. This restriction in the field of vision is one of the most valuable points in the diagnosis when it is otherwise difficult on account of opacity of the lens. The scotoma, too, may diminish in size, from absorption of extravasated blood, or increase, as the subsequent exudation becomes denser and more copious.

Treatment.—The successful removal of foreign bodies from the vitreous and back of the eye was, until comparatively recently, of so excessively rare occurrence that practically the chances of an operation undertaken for that purpose being successful were nil. Now, by the aid of the magnet, a good many eyes can be saved which must previously have been lost. By this means only particles of iron and steel can, under favourable circumstances, be removed, while with regard to other bodies we are not better situated than before. Iron and steel particles form, however, a large proportion of all the cases met with.

In cases of portions of non-magnetisable metals in the vitreous, an immediate operation is hardly justifiable, as the chance, small as it is, of the foreign body being encapsuled, or leading to relatively little irritation, is still greater than that of one's being able successfully to remove it. The removal may be attempted in the secondary stage, however, when the patient has been prepared for the alternative treatment of evisceration or enucleation of the eye should the attempt fail, as it is likely to do. In any case, the incision should be made radially and not circularly in the sclera, and at the lower part, except where a point of marked tenderness exists in some other situation, when that point should be selected instead. Bodies fixed in the coats of the eye may occasionally be seized with forceps and withdrawn, and a relatively good result be obtained.

Unfortunately the advisability of performing any operation for the removal of foreign bodies from the eye is often questionable, on account of the risk which is then run from sympathetic inflammation occurring sooner or later in the other eye. When the injury has been so severe as to destroy vision from the first, there can be no hesitation about removing an eye in which a foreign body is lodged. If this can be done within the first week, evisceration is the most satisfactory operation—if later on, enucleation. A difficulty in deciding arises in most of the cases where some vision is retained, and here much will depend on the course taken by the inflammation. This is especially the case where the foreign body is a shot pellet. When the penetration has taken place through the sclera, and the wound made in it is small, there is not much danger of any septic matter having been introduced at the same time, so that it is generally advisable to make an attempt to keep the eye. Where the exudation can be made out to be extending, removal of the eye should be advised; but an attempt may first be made to extract the foreign body, if the patient thoroughly understands the risk which he still runs, even if this should be successful. Other points in this connection are discussed in the next chapter.

CHAPTER XII.

SYMPATHETIC OPHTHALMITIS.

A GREAT number of affections of the eye are, or are supposed to be, in some measure caused by inflammatory conditions which have pre-existed in the other eye, and are consequently looked upon as *sympathetic*.

The disease which is generally spoken of as sympathetic ophthalmitis is an inflammation of the uveal tract, more especially of its ciliary portion, which comes on—rarely sooner than three weeks, and often much longer—after some injury or affection of the other eye, which has been followed by more or less destructive inflammation in it.

There is nothing absolutely characteristic about a sympathetic ophthalmitis; it may be acute, but it is more often distinctly chronic. It may be mild from the first, or of a decidedly malignant type, and it may be recovered from, or lead to considerable or to complete blindness. An inflammation of the eye which is sympathetic in this sense is usually very protracted. It is either altogether painless, or accompanied by but little pain.

In connection with this subject it is convenient and customary to use the following terms. The eye first affected is called the *exciting* eye, or shortly the *exciter*; the other, the *sympathising* eye, or the *sympathiser*.

The inflammation in the sympathising eye, although its progress may be slow, and unaccompanied by well-marked external signs of inflammation, gradually gives rise to all the changes, and is very liable to be followed by the worst consequences, of a severe irido-cyclitis. The first symptom that is often noticed is a defective degree of accommodative power, causing a difficulty of seeing things distinctly near at hand. Some turbidity of the aqueous humour, most noticeable in the area covering the pupil, may frequently be made out about the same time. The iris then loses its glistening appearance and becomes muddy and

discoloured, while synechiæ form between it and the lens capsule. There is tenderness on pressure over the ciliary region, the vitreous humour becomes clouded with opacities, and the tension of the eye, which may at first be increased, becomes diminished. A new formation of vessels takes place in the iris, which assumes a greyish colour, and a tumefied, unhealthy, spongy appearance. A membrane soon forms across the pupil, the anterior chamber becomes shallowed, while the periphery of the iris is often to some extent retracted. Detachment of the retina gradually takes place, owing possibly to the traction in, and certainly to changes in the character of, the vitreous, and leads to complete blindness. But the inflammation may subside before this stage is reached, and a certain amount of vision be retained, along with the appearances of a greyish, thickened, and at the same time atrophic, iris.

Sympathetic ophthalmitis sometimes takes the form of a serous irido-cyclitis from the first. When the inflammation in these cases subsides, as it is more likely to do than in the malignant plastic form, fair or even very good vision may be retained, but even such cases may go on to complete blindness.

Some cases are preceded by what is called *sympathetic irritation*—that is to say, that while as yet there are no signs of actual inflammation, there may be photophobia, lachrymation, and pain referred to the back of the eye and to the forehead. This irritation is in all respects similar to that experienced in the other eye when a foreign body lodges in the opposite conjunctival sac, or causes some abrasion of the cornea. When to these symptoms of irritation are added circumcorneal injection, there is reason to fear an attack of sympathetic ophthalmitis. But the symptoms of sympathetic irritation may continue to exist without ever passing on to the dreaded inflammation. On this account it is of importance to make a clear clinical distinction between irritation and sympathetic ophthalmitis. Sympathetic irritation is at once cured by removal of the exciting eye, while such is by no means the case in sympathetic ophthalmitis.

As a general rule, we may take it that where cyclitis of one eye sets up a sympathetic cyclitis in the other, the exciting eye has either never come properly to rest since the accident or disease which caused this inflammation, or else fresh irritation has begun after a period of more or less prolonged quiescence. The renewed inflammation may not be accompanied by very marked symptoms, but there will always be found some degree of tenderness to pressure over the ciliary region. Often there

is, besides this evidence of cyclitis, circumcorneal injection, lachrymation, and sensitiveness to light. A reinflammation is a common occurrence in cases where foreign bodies are lodged in the eye, owing to their having spontaneously, or through some possibly very slight accident, become dislodged from their encapsuled position. This possibility has therefore to be borne in mind in all cases where a foreign body is known to be retained in the eye, even although comparatively trifling irritation may have followed the accident. As long as the eye remains quiescent there is little or no danger, but the patient must be warned of the risk he runs in keeping the eye, and be urgently cautioned to seek advice as soon as tenderness or redness should at any time manifest themselves. Blows, too, on previously injured or diseased eyes are liable to set up fresh inflammation, and thus lead to sympathy.

The condition of the exciting eye at the time of its causing sympathy is one not merely of inflammation alone, but of inflammation which is not sufficiently severe to cause purulent destruction of the tissues, and which at the same time is not accompanied by so much serous discharge as to give rise to prolonged increased tension. Sympathetic ophthalmitis very rarely results from panophthalmitis, and all the more rarely the more complete has been the destruction by the purulent inflammation.

A glaucomatous condition of the eye, too, whether arising from increased transudation or impeded excretion, is very rarely associated with a condition liable to excite sympathetic inflammation. *A soft eye, in which perforation, either from accident or ulceration, has at any time taken place, and which is tender to pressure, is that which endangers the safety of the other.* Often such eyes are at the same time blind, but this is not always the case, although it is rare that they have retained any considerable degree of visual acuity.

Sympathetic ophthalmitis is most frequently the result of some injury to the other eye; the wounds which give rise to it may occur in any part of the eye. Wounds in the ciliary region, or extensive cuts involving the ciliary region, and at the same time leading to considerable loss of vitreous humour, are the most dangerous in this respect. Mere corneal wounds may be followed by sympathy, but in such cases they are probably always sufficiently severe, either in extent or from the manner in which they have been inflicted, to give rise to more deep-seated inflammation in the eye.

The excitation may also arise from operations performed on the eye. Of these causes the most common are extractions of

cataract, especially in such cases where, from encleisis of the iris or vitreous, the healing process has been slow and accompanied by considerable inflammatory reaction. Other operations occasionally followed by sympathy are—needling for after-cataract, iridectomy, and abscission of staphylomata.

Of the spontaneous diseases of the eye which produce ophthalmitis in the other, the most common are the various forms of perforating ulceration of the cornea, especially when such perforation is followed by more deep-seated inflammation and shrinking of the eye. Curiously enough, however, *a perforation which has arisen from within is not so liable to be followed by sympathetic ophthalmitis as one which has taken place from without.* Intra-ocular tumours, when they set up cyclitis, may also occasion sympathy, though this probably does not occur until they have reached the third stage, and produced perforation of the coats of the eye.

The question as to whether or not true sympathetic inflammation ever occurs where there has at no time been perforation of the eye is one which can hardly be said to be yet decided. All cases in which a destructive form of cyclitis or other uveitis occurs first in one eye and then in the other are of course not necessarily of a sympathetic nature. The real difficulty in all non-traumatic cases is to determine whether the second eye is affected on account of the first, or whether the disease in both is not due to the same cause, as so often happens in iritis, in glaucoma, cataract, and other affections of the eye. Only in cases where the first eye has been injured without being perforated, and become inflamed, and been subsequently followed by cyclitis in the second eye, could the presumption be greatly in favour of the sympathetic nature of the cyclitis in the second eye.

The interval which elapses between the injury to the first eye and the outbreak of sympathetic inflammation of the second is very variable. It is rarely less than three weeks, and may be longer than thirty years. In one of my cases it occurred after forty-two years.

So far as any practical considerations are concerned, there is no difference in the severity or result of the sympathetic inflammation whether a short or a long interval intervene between the primary lesion and the characteristic changes in the sympathising eye.

Treatment. — Though fortunately by no means a common occurrence, sympathetic inflammation is of such serious importance that every medical man should be alive to the conditions which are liable to give rise to it.

The exact nature of this spreading of an irido-cyclitis, of often the most malignant type, from one eye to the other is still unknown. All the clinical facts are, however, so strongly suggestive of the correctness of the view which ascribes the sympathetic inflammation to changes supervening upon a microbic inoculation of the eye which is first inflamed, that it is practically important to act as if this view were an established fact.

It is true that the experimental as well as the bacteriological evidence have failed to confirm the idea that micro-organisms introduced into the one eye actually find their way by some channel or other into the second eye, and there set up their pathogenic action. It has not, however, been shown that toxins formed by the action of germs in the first eye do not pass over to the second. The clinical features of sympathetic ophthalmitis are indeed so consistent with this possible origin, that it should, at all events in the meantime, be accepted as a useful working hypothesis. The first eye must be looked upon as the site of production of a poison of microbic origin, even although the actual existence of the specific microbe has so far escaped detection.

The facts to be kept in mind are—that sympathetic inflammation of the second eye practically only occurs where the first has been perforated by injury or disease, and that some time must elapse between this perforation and the beginning of symptoms of sympathetic inflammation.

The indications for preventive treatment are therefore to remove or otherwise destroy the source from which the poison is distributed, and to do so within a limited time. Cases in which perforation is caused by injury, and particularly those in which the perforating body becomes lodged in the eye, present the greatest risk of exciting sympathetic mischief. It is generally asserted, too, that there are special risks in this respect connected with wounds of the eye which involve the ciliary body. I do not think that experience altogether warrants this belief. Wounds in this region are, on the whole, less liable to heal rapidly, and this circumstance, in the case of microbic infection at the time of injury, may possibly create a greater tendency to the conditions favouring the elaboration of the specific poison. Certainly there is no greater risk attaching to clean wounds in the ciliary region than to similar wounds in other parts of the eye.

The special risks are, then, wounds of the eye caused by bodies which are likely to have led to the introduction of micro-organisms. More especially, however, has the state of the eye

which follows injuries of such a nature to be taken into consideration. The risk is greatest where it remains irritable and congested over an area which is often limited to that surrounding the site of an enclosed foreign body, or, in the absence of any foreign body, to the neighbourhood of the external wound. When this irritability is associated with marked tenderness on pressure, there is special cause for apprehension.

In the risky cases, the irido-cyclitis which gives rise to these symptoms of irritation is more fibrino-plastic than purulent. Anything like a rapid purulent destruction of an eye following injury, or the perforation of a corneal ulcer, is not likely to be followed by sympathetic changes in the other eye. Either the specific toxins are then not formed, from the absence of the specific germs, or from the preponderating, more rapid action of pus-forming organisms, or the channels by which these toxins reach to the other side are sealed and destroyed by the purulent process. Whatever the cause, the clinical fact should be remembered. But it must not be supposed that the mere presence of pus precludes the likelihood of sympathetic inflammation. It is only in the cases in which rapid and extensive purulent destruction results from an injury that this is so. A little hypopyon making its appearance slowly after injury is not only for the most part evidence of the introduction of microbes into the eye, but is a complication which is frequently met with in cases which are afterwards associated with sympathetic irido-cyclitis of the other eye.

We have to consider not only the treatment most suitable for sympathetic ophthalmitis when it has made its appearance, but also the means of preventing it. It must be confessed that in both cases it is often a matter of very great difficulty to decide upon what is right to do.

There can be no doubt that the removal of the one eye is capable of preventing a sympathetic inflammation of the other eye, which might otherwise take place. If it always did so, much of the difficulty in dealing with cases liable to excite sympathetic inflammation would disappear. If the injured eye is removed within forty-eight hours, sympathetic inflammation will never occur; and it is, practically speaking, prevented by enucleation performed any time within the first week after injury. Often the date at which an eye which may excite inflammation in the other is removed is, owing to different circumstances, much later. It occasionally happens, then, though perhaps less frequently relatively than some suppose, that the other eye is affected after complete removal of the injured

or diseased one. As, however, it is very easy to overlook the first onset of inflammation in the sympathising eye, it is more than probable that many cases recorded as first beginning after enucleation have in reality begun before, and escaped observation. Practically: *if three weeks have elapsed since enucleation, there is still a possibility, but extremely little probability, of the remaining eye, if it has previously been sound, becoming affected, while after two months it may be considered absolutely safe.*

These clinical facts are important, and have to be kept in view. They at all events make the decision, of what should be done, easy in the case of blind eyes. When, for instance, a recent injury of such a nature as would be likely to introduce septic matter into the eye has at the same time caused irreparable blindness, there can be no question as to the advisability of enucleation. Suffering will be prevented, and any risk of a much greater misfortune will be obviated by resorting to this measure. It should therefore be urged upon the patient as strongly as possible. A similar proceeding is indicated where a previously injured and sightless eye has become irritable and tender to pressure. Only if the irritation is due to increased tension—a secondary glaucoma—is the necessity for interference of this nature uncalled for.

Injured eyes are, however, far from being always completely blind. In many instances, indeed, a useful degree of vision may still remain, and yet they cannot be looked upon, it may be, as safe in regard to the risk in question. Here it is that the difficulty of determining upon the adoption of the prophylactic effect of enucleation asserts itself. The difficulty is not so great, no doubt, in the case of recent injuries, because at all events the prophylaxis is certain. Even if the surgeon should consider it necessary to remove such an eye, it may not be easy to obtain the patient's consent.

In other cases, however, in coming to a decision as to whether a not altogether blind eye, which has been exceedingly irritable for some weeks after injury, or has again become inflamed after a longer period of quiescence, should be sacrificed in the interest of the other, one has to face the possibility of this measure, if adopted, not succeeding in preventing sympathetic inflammation. Under such circumstances, if the second eye should eventually be lost by irido-cyclitis, one might have to blame one's-self for having removed the only chance of some remaining sight.

With regard to the inflammation in the sympathising eye, which only comes on within a short time after excision of the

exciting eye, the question naturally arises, Is it as severe and intractable as that which is met with where the exciting eye has not been removed? The answer to this is, that whilst on the average it is less severe and more amenable to treatment, experience has shown that it may be quite as disastrous. The same may be said of the effect of enucleation of the exciting eye, when undertaken after sympathetic inflammation has begun. There is then, at all events, a chance that the secondary process may be checked at an earlier stage than would be the case if the source of excitation were allowed to remain.

What applies to enucleation as a prophylactic measure applies equally to evisceration. A properly performed evisceration is capable, under practically the same restrictions, of preventing the occurrence of sympathetic ophthalmitis. It is, however, essential that the evisceration should be complete, and that absolutely no trace of any other parts of the eye should be left within the scleral shell.

Section of the optic nerve without removal of, and with excision of, a piece of the nerve—neurotomy and neurectomy—have also been advocated, but are undoubtedly inferior prophylactic measures.

If the prophylactic treatment may offer difficulties, the difficulties in connection with the treatment of an actual sympathetic irido-cyclitis are still greater. The first thing to do, as soon as ever any circumcorneal injection or loss of gloss of iris surface shows itself in the second eye, is to use atropine freely until the pupil is widely dilated.

The tendency for the pupil to become entirely blocked by exudation is so great, that every effort must be directed to keeping it as wide as possible. If this should cause tension, I believe the best treatment, under the circumstances, is to perform sclerotomy. This is preferably done by means of a peripheral incision with a triangular-shaped keratome. Iridectomy should not be done at first, but the sclerotomy, which need not be very large, may be repeated several times.

On the cessation of the inflammation, which usually lasts for months, and after the eye has been quiet for some weeks, a large iridectomy should be made. Even then there is a great chance of the aperture made becoming occluded. When this happens, and after the eye comes to rest, if it still retains some vision, even if it merely be perception of light, the best thing to do is to remove the lens through an incision, as if for cataract extraction, made along the corneo-scleral margin.

Even this does not always result in a permanently open pupil.

It may then be necessary, after a further period of inflammation, followed by quiescence, to perform an iridotomy, cutting through the matted-down iris and organised exudation with a sharp knife or scissors made for the purpose. In this way I have sometimes succeeded in restoring a useful amount of vision after a long period of practical blindness. In many cases degenerative changes have supervened, following upon continued inflammation, before this amount of interference is possible.

Fig. 149.—Evisceration scoop.

Medical treatment is of little use. Mercurial inunction should be tried, and the pain, when it is present, may be allayed by hot sponging and antipyrin.

Evisceration of the globe.—The instruments required for this operation are a speculum and fixation forceps, a Graefe's knife, a pair of scissors, and a blunt Volkmann's spoon. The conjunctiva is first undermined for a short distance all round the cornea. The anterior chamber is then transfixed on a level with the horizontal meridian of the cornea, and a section made which completely separates the lower portion of the cornea from the sclera along the junction between them. The flap of cornea thus formed is then seized with the forceps, and the rest of the cornea separated with the scissors. With a special form of shovel scoop (Fig. 149) the whole contents of the globe can now be evacuated. This must be done thoroughly, so that nothing is left but the sclera. When the bleeding which this causes has been stopped by means of pledgets of cotton-wool introduced into the cavity, the edges of the sclera are brought together with three vertically laid catgut sutures. The conjunctiva is then stitched up in the same way, the sutures being, however, laid horizontally.

This operation is often followed by considerable œdematous infiltration of the tissues, and pain, which may last from twenty-four to forty-eight hours. I have not found that the introduction of horse-hair or catgut as a drain has modified the severity of the infiltration, although it has been recommended for this purpose. The stump left, though admitting of a better movement in an artificial eye than results from enucleation of the

eye altogether, is yet not so markedly better in this respect as might be supposed from the appearance shortly after operation. A very great degree of shrinking takes place in the course of time, so that the pad on which the muscles act is greatly reduced in size. To obviate this defect, a modification of the operation was recommended by Mules, which consists in introducing a glass ball into the scleral cavity and uniting the conjunctiva over this. My own experience of Mules' operation has not been particularly encouraging. In a great many cases the glass ball seems to be expelled sooner or later by ulceration of the overlying tissues; but the eventual result in such cases does not appear to be worse than if the attempt had not been made, although the patient is necessarily subjected to a somewhat prolonged treatment. When the operation does succeed, the effect, so far as the movements of the artificial eye—which rests on this artificial stump—go, could hardly be more beautiful.

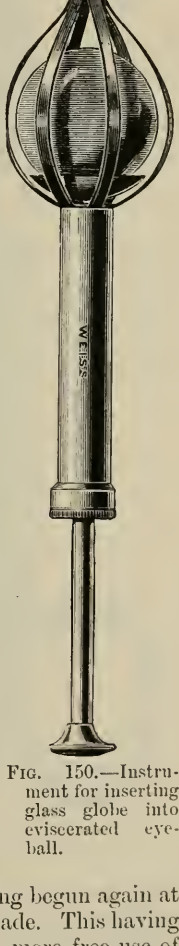


FIG. 150.—Instrument for inserting glass globe into eviscerated eyeball.

Enucleation of the eyeball.—The instruments required for enucleation are a speculum, fixation forceps, strabismus hook, and a pair of strong scissors curved on the flat. Anæsthetics should generally be used, though the pain may be to a great extent mitigated by the free use of cocaine during the operation.

The conjunctiva immediately surrounding the cornea is first incised. This is best done by catching hold of a portion of the upper part with the forceps, snipping through it with the scissors, and then passing one blade behind, allowing it to glide beneath the conjunctiva to one side of the cornea, while the other blade remains external to the conjunctiva. In this way one or two cuts with the scissors will suffice to complete the division of one-half of the conjunctiva surrounding the cornea, while the other half may be divided by using the blades in the same way along the other side, after having begun again at the point above, where the first perforation was made. This having been done, the capsule of Tenon is opened by a more free use of the scissors at the lower portion, just over the inferior rectus.

The strabismus hook is then passed under the inferior rectus, which is divided close to its insertion. The hook may now be swept in succession round each of the recti muscles, and their insertion severed from the globe in the same way. After dividing the insertion of the superior rectus, the hook should be passed deeper, so as to hook up the superior oblique, which must also be divided in the same way. The branches of the speculum are then separated as much as possible, and the eye allowed to protrude. The scissors must next be passed in between the capsule and the globe to the back of the eye, the blades being kept closed until the points are felt to touch the optic nerve. They are then opened and pushed a little farther, so as to cause the blades to pass one on either side of the nerve, which is cut across with a firm snip. The eye can now be drawn forwards, as it is only held by a few bands of connective tissue, which have to be snipped across to complete its removal. The bleeding is readily stopped with pledgets of cotton-wool. The proper arresting of the bleeding, as well as careful antiseptic treatment throughout, should be attended to, as these points are of importance in ensuring the speedy healing of the wound left in the orbit. A tight bandage should be applied and kept on for four or five hours, so as to prevent any infiltration of the tissues with blood. Afterwards nothing is required but attention to the cleanliness of the wound by frequent syringing or bathing with corrosive sublimate solution. It is a good plan,

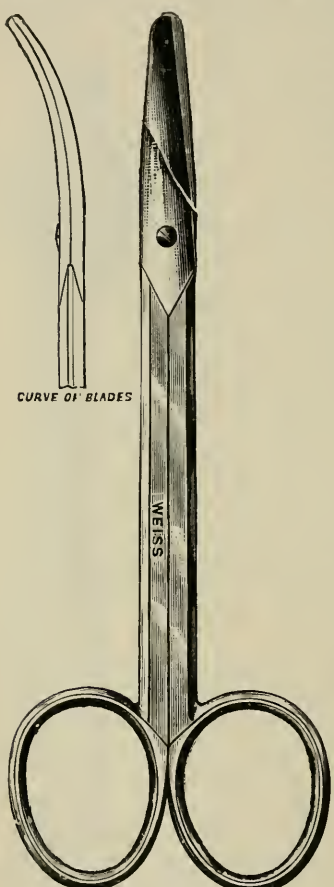


FIG. 151.—Enucleation scissors.

too, to smear a little lard along the edges of the lids at night, so as to prevent any retention of the secretions.

An artificial eye should not be worn for about two months. The eye, when worn, should be removed every night, and kept in water containing a little antiseptic. When it becomes corroded, it should be repolished, and at any time any irritation which it may produce should be taken by the patient as a warning that its use should be left off for some time.

There is a great tendency amongst the wearers of artificial eyes to have them too big. They do not, in looking at themselves in the glass, appreciate the staring appearance of such an eye. It is better to have one of such a size that the lid droops slightly over it, as compared with the other eye. Such an eye is not only less likely to set up irritation, but is also much more deceptive.

Operations are sometimes required to render the socket better fitted to lodge an artificial eye. No definite rules can be laid down for such operations. The surgeon must be guided by the conditions presented by each individual case. Sometimes, owing to the tendency to drooping of the lower lid, it is necessary to raise it by uniting the upper and lower lids at the outer canthus.

CHAPTER XIII.

GLAUCOMA.

The chief objective signs of glaucoma are—(1) Increased intra-ocular tension; (2) dilatation and immobility of the pupil; (3) haziness of the cornea; (4) shallowness of the anterior chamber; (5) enlargement of episcleral veins; (6) excavation of papilla; (7) visible pulsation of the retinal artery.

At the same time the following subjective symptoms are met with—(1) Defective central vision; (2) more or less characteristic limitation of the field of vision; (3) photopsia; (4) anæsthesia of the cornea; (5) pain.

A marked and important characteristic of glaucoma is the intermittent nature of both objective and subjective symptoms. This intermittency is met with at all stages of the disease, and even persists when the eye is totally blind, subjective light sensations and pain coming on every now and then, and at other times being wholly absent.

From a clinical point of view the following forms of glaucoma should be distinguished:—

A. Primary glaucoma.
1. Congestive glaucoma.
(α) Acute. (β) Chronic.
2. Non-congestive glaucoma.

B. Secondary glaucoma.

We may distinguish three stages of the disease, in whatever form it is met with—(1) The *threatened* stage, in which the premonitory symptoms to be shortly described assert themselves; (2) the *confirmed* stage, in which the disease has led to defective vision, which gradually increases until (3) the glaucoma is said to be *absolute*, or has resulted in complete destruction of vision. In many cases degenerative changes have already begun by the time the absolute stage is reached; in all cases such changes eventually make their appearance.

Primary glaucoma is essentially a disease of advanced life;

it is rarely met with before the age of forty, and increases in frequency with age. It is most common for both eyes to be subject to attacks of glaucoma.

In a certain proportion of cases of glaucoma, variously estimated at from one-third to three-fourths of all cases, the actual outbreak of the disease is preceded by premonitory symptoms, more or less marked, and occurring at, as well as extending over, longer or shorter periods of time. What distinguishes the disease in this stage from that in which it may be said to be fully developed, is that during the intervals between the occurrence of these symptoms the functions of the eye are to all appearance normal.

The *premonitory symptoms* are obscurations of vision and the appearance of haloes round lights. The vision appears more or less misty and veiled, this being especially noticeable for objects which are not very strongly illuminated. At the same time, if the flame of a candle or gas jet be looked at against a dark background, it is seen to be surrounded by a colourless space, which is encircled by a coloured halo, the intensity of which differs in different cases, as well as at different times in the same case. These symptoms usually come on after some mental or physical fatigue, *e.g.*, a sleepless night, or prolonged fasting. They disappear after a meal, and more constantly after sleep, and can also almost invariably be cut short by the use of a miotic. The intervals between such attacks are very variable, often amounting to months or years, but usually having a tendency to become shorter and shorter, until the glaucoma suddenly or gradually passes from the premonitory to the confirmed stage.

Premonitory symptoms appear to be on the whole more common the younger the individual attacked with glaucoma. The cloudy vision varies in amount, but may be very disagreeable to the patient at a time when he is found on examination to have full visual acuity, although, as a rule, it is accompanied by some diminution in the acuteness of vision. The halo seen is always perfectly circular. Its apparent size increases, and the breadth of each coloured ring becomes greater the farther the light is from the eye.

During the premonitory attack the tension of the eye is always increased, and there is more or less diffuse opacity of the cornea. Sometimes, however, the opacity is so slight as to be barely noticeable on oblique illumination. There can be little doubt that the haloes are due to the diffraction of the rays passing into the eyes, and this diffraction probably mainly takes place in the cornea as the result of the opacity.

The obscurations of vision are also to a great extent, though probably not entirely, due to the opacity of the cornea.

The vision of haloes round lights is not altogether pathognomonic of glaucoma. It is met with, for instance, in cases of conjunctivitis, owing to the diffraction caused by the conjunctival secretion lying in front of the cornea. In such cases the haloes disappear on rubbing the eye. A good many people, too, with normal eyes see them, especially if the pupil is dilated. They are probably, however, rarely seen of the same intensity as in glaucoma, so that when suddenly observed they should awaken suspicion.

If an ophthalmoscopic examination be made at the time when the premonitory symptoms are complained of, there is sometimes seen to be a spontaneous pulsation of the arteries on the disc. This appearance disappears with the disappearance of the subjective symptoms, and of the increase of intra-ocular tension. The same pulsation may be produced by external pressure on the eye; and in cases where the intra-ocular tension is increased, and yet the pulsation not visible, it may often readily be elicited by slight pressure on the eye with the finger.

The *increased intra-ocular tension* is not always present at the time of examination of an eye affected with glaucoma. During an attack, when the cornea is hazy, the vision more interfered with than usual, and the patient suffering pain in the eye and over other parts in the region of distribution of the fifth nerve, increased tension is rarely if ever absent. In the non-congestive form of glaucoma it is usually less constant and less pronounced than in that in which there exists an evident congestion. The degree of intra-ocular tension is subject to considerable differences physiologically, some eyes being distinctly harder than others, and for this reason it is not by any means easy to feel sure in any particular case that the tension is higher than normal. If, for other reasons, one is led to suspect a possibly increased tension in one eye only, it should be compared carefully with the other, which affords the best standard for judging of the tension in the doubtful one.

Various instruments, called tonometers, have been devised for the purpose of measuring the intra-ocular tension, but none of these appear to afford any more delicate or more trustworthy information than is given by palpation with the ends of the fingers.

Two ways of making such palpation may be employed. The point of each forefinger may be placed on the closed eye, and alternately pressed gently upon the globe through the upper lid;

or the forefinger of one hand may be applied directly to the conjunctiva covering the sclera when the eye is directed upwards, and a series of slight taps given, without at any time removing the finger altogether from contact with the eye. In either of these ways the resistance of the eye can be determined with considerable delicacy, so that a little practice suffices to enable one to gauge the relative hardness of two eyes tested at the same time. It is more difficult to acquire the power of estimating the amount of change in tension. It is customary to distinguish three degrees of increased hardness. These three degrees, which were pointed out by Bowman as practically distinguishable, are—(1) A marked increase, as compared with the normal, or T + 1 according to Bowman's notation; (2) a great increase, but one in which, to the palpating finger-points, the eyeball still admits of some dimpling, T + 2; and (3) that degree of tension upon which little impression is made, even by firm pressure on the eye, T + 3. A doubtful increase may be noted as T + ?

While such a division is extremely practical and universally adopted, it must not be supposed that any hard-and-fast line exists between the different degrees of increased tension; thus it is not an uncommon thing to find a particular degree of tension denoted by one examiner as T + 1, and by another, equally practised, as T + 2. This is, however, a matter of little importance, as under such circumstances there is no doubt as to the abnormal degree of tension. The more important cases are those in which there may be a difference of opinion as to whether any increase in tension exists at all.

Dilatation of the pupil, along with more or less complete immobility, is very constant in glaucoma. The dilatation is not always regular, and the pupil is frequently oval or egg-shaped, owing to greater dilatation at some parts than at others. This is a point of some importance in connection with the differential diagnosis between simple, non-congestive glaucoma and optic atrophy. The eye presents at the same time a muddy appearance, and the pupil frequently has that greyish-green colour which gave rise to the name of glaucoma. This is due to the reflection of light from the surface of the lens, modified to some extent by the haze of the cornea, and apparent on account of the dilatation of the pupil. The pupil may be got to contract by the use of the eserine, and to dilate still further by atropine, in most cases where the iris tissue has not undergone an atrophic change—most readily therefore, on the whole, in early cases.

The haziness of the cornea is a constant appearance during the period of exacerbation in all congestive cases. In chronic non-

congestive cases it is often absent, or present only to a very slight extent, though at times, when the tension is high, it may even in such cases be sufficiently evident. The peculiarity of the corneal haze in glaucoma is that it is continuous and most intense toward the centre of the cornea. It is always accompanied by a dull and somewhat stippled appearance of the surface. A characteristic, too, is the disappearance of the haze immediately on, or very soon after, the return of the tension to the normal.

Shallowness of the anterior chamber is almost invariably met with to a greater or less extent, though sometimes the opposite condition occurs. In most cases where glaucoma occurs in young individuals, the anterior chamber, instead of being shallow, is abnormally deep, owing to the retention of liquid in the anterior chamber. This is also the case in some forms of secondary glaucoma.

Enlargement of episcleral veins occurs in most cases which have existed for some time, more especially in the congestive form of the disease, though this change is rarely absent altogether, even in cases of simple glaucoma. In acute congestive glaucoma we meet with hyperæmia and chemosis instead, as the result of the sudden disturbance in the venous circulation within the eye, which, when long continued, is the cause of the distension of the external veins.

Excavation of the papilla—the so-called glaucoma cupping—is met with sooner or later in all cases of glaucoma, but the extent of the cupping does not stand in any very close relation to the degree of visual defect. When fully developed, the papilla in glaucoma presents the following appearances on ophthalmoscopic examination. The vessels are pushed to the inner or nasal side, and appear to bend sharply round the margin of the disc in this situation, without therefore coursing over any portion of normal papilla, the veins being at the same time frequently distended and the arteries small. The rest of the papilla presents a greyish-blue appearance, which is seldom uniform, being more frequently specked with white, especially at the centre. There is besides, when the retinal vessels are not very greatly atrophied, a blurred appearance of vessels to be seen in this bluish area. Surrounding the papilla there is almost invariably a whitish-yellow ring, the breadth of which varies considerably in different cases, but which seldom measures more than one-fourth or one-third the breadth of the papilla. The breadth is as a rule uniform throughout.

Even a slight degree of excavation can be readily diagnosed,

by the indirect method of ophthalmoscopic examination, by observing the parallax caused by moving the lens from side to side. The edges of the papilla are in this way seen to apparently slide back and forwards over the central part. From this we know that the aerial image of the borders of the disc lies nearer the observer than that of the centre of the disc, and consequently is that of an object whose distance behind the cornea is less. The actual depth of the excavation can be approximately determined by estimating the refraction by direct ophthalmoscopic examina-

Fig. 152.—From a case of glaucoma, showing vessels pushed to nasal side of disc, over the margin of which they suddenly dip: also the halo of degeneration round the disc and the cupping with the central vessels out of focus (typical glaucomatous excavation of optic nerve).

tion of the margin and of the centre or deepest part of the cup, and allowing three dioptres to every millimetre.

There is little difficulty, as a rule, in diagnosing a glaucoma excavation when fully formed, but the less marked changes which occur at first are by no means always entirely characteristic, and may be confounded with physiological excavation, and also with that excavation which is met with in atrophy of the nerve. When the visual defect is inappreciable, the glaucoma excavation may be taken for a physiological one; while, on the other hand, in cases where, from some cause or other, vision is at the same

time impaired, one is apt to ascribe undue importance to an existing physiological excavation. The physiological excavation is white, and never involves very much of the nasal part of the disc, over which the vessels can consequently always be seen to course. When large, it may extend over a large part, or even the whole, of the temporal half. The vessels can generally be followed down the side of the excavation, which is funnel-shaped, and not steep, as that met with in glaucoma. In cases

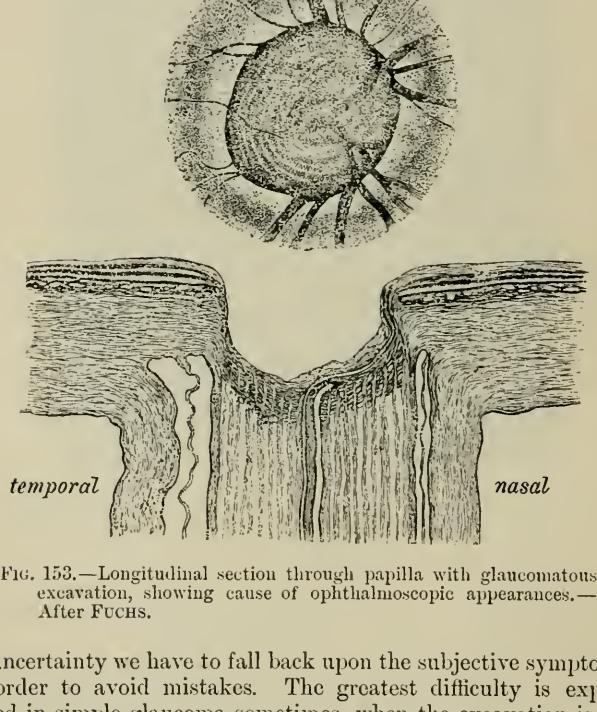


Fig. 153.—Longitudinal section through papilla with glaucomatous excavation, showing cause of ophthalmoscopic appearances.—After Fuchs.

of uncertainty we have to fall back upon the subjective symptoms, in order to avoid mistakes. The greatest difficulty is experienced in simple glaucoma sometimes, when the excavation is not very characteristic, as the subjective symptoms are hardly distinguishable from those accompanying atrophy. The atrophic excavation is shallow, and as a rule occupies the whole disc. The vessels never bend sharply over the margin of the disc, and can be seen, more or less out of focus, continually from the point

or points at which they emerge from the nerve. The appearances, which of themselves would tend to render glaucoma the probable cause of the excavation, should it be slight and not very typical, are the crowding of the vessels to the nasal side of the disc, and the yellowish ring surrounding the disc. The straight dipping of all the vessels, which is met with in a later stage, is quite characteristic.

A spontaneous pulsation of the retinal arteries on the cupped disc is almost a certain proof of the existence of glaucoma. Such visible arterial pulsation is very rare under other circumstances. It is due to some resistance to the flow of blood through the retinal arteries, so that the current is only complete during a systole. The impediment is mainly, no doubt, the result of increased intra-ocular pressure on the vessels, but it

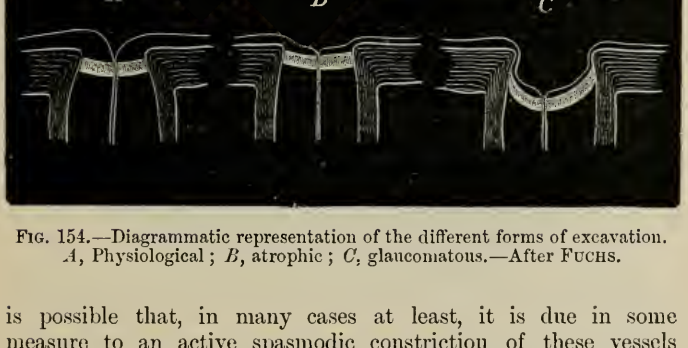


Fig. 154.—Diagrammatic representation of the different forms of excavation. *A*, Physiological; *B*, atrophic; *C*, glaucomatous.—After Fuchs.

is possible that, in many cases at least, it is due in some measure to an active spasmodic constriction of these vessels themselves. It disappears almost invariably after iridectomy, and cases where this pulsation is visible are such as are most likely to be benefited by operation.

The cause of the excavation of the papilla in glaucoma is the gradual recession of the lamina cribrosa. This structure is unable to resist for long the increased pressure to which it is subjected, so that after frequent attacks of abnormal tension the end of the nerve becomes hollowed out. The excavation of the papilla depends in all probability less on the degree than on the duration of the increased tension. The yellow ring is generally believed to be due to some atrophy of the choroid caused by pressure or distension as the lamina cribrosa recedes.

The acuteness of vision begins to diminish and become permanently impaired as soon as the glaucoma has passed from the premonitory to the fully developed stage. During the existence of premonitory symptoms more or less diminution of vision takes place, but this is recovered from as soon as the attack passes off. Even in cases which have advanced to true glaucoma we may usually distinguish between a permanent and a transitory element in the blindness. During each exacerbation which occurs in a case of congestive glaucoma the vision is worse than before; after the acute symptoms subside there is a gradual recovery to a certain extent, which, however, does not as a rule lead to a restoration of the same degree of acuteness which existed before the attack. Each attack, therefore, leaves vision more impaired than before, until it is eventually lost altogether.

There is a very great difference in the rapidity with which complete destruction of vision takes place, a difference which depends on the nature and severity as well as the frequency of the acute attacks, and also upon the continuance of the increased tension. In the most acute cases, where the symptoms of congestion are excessive, vision may be altogether lost in a few hours. To such cases the name *glaucoma fulminans* has been given; while, on the other hand, chronic cases, and more particularly chronic non-congestive cases, may not lead to the complete loss of vision until after the lapse of many years.

Restriction of the field of vision occurs at the same time as the defect in the acuteness of central vision. There is no absolute constancy in the manner in which the field of vision is invaded, but most frequently one finds the nasal portion abolished to a greater extent at first than other portions of the field, and not infrequently this portion alone can be demonstrated to be defective. Wherever the restriction is, it is generally continuous; that is to say, there are not, as a rule, scotomata, but if one part of the retina has lost its function, that of the parts more peripheral to it in the same direction is mostly also abolished. The blind portion of the field of vision is bordered by an amblyopic area in which colour vision is either absent or defective, but there is not the same recession of the boundaries for colour vision as is met with in atrophy of the optic nerve. The limit at which the different colours are recognisable is usually much the same for all, and only slightly narrower than the corresponding boundary for uncoloured impressions, while even in cases where the limitation is very great there still remains colour perception. It is the rule for

this greater restriction to the nasal side of the field to progress and eventually involve the centre before complete blindness sets in, so that at an advanced stage of the disease only an eccentric portion of the temporal side remains. The preponderance of the nasal invasion of the field appears to be more common in chronic than in acute cases of glaucoma. The manner of restriction next most frequently met with is the concentric restriction, where there is a tolerably proportionate interference with the function of all parts of the periphery of the retina. It is very rare indeed to find the restriction most marked outwards.

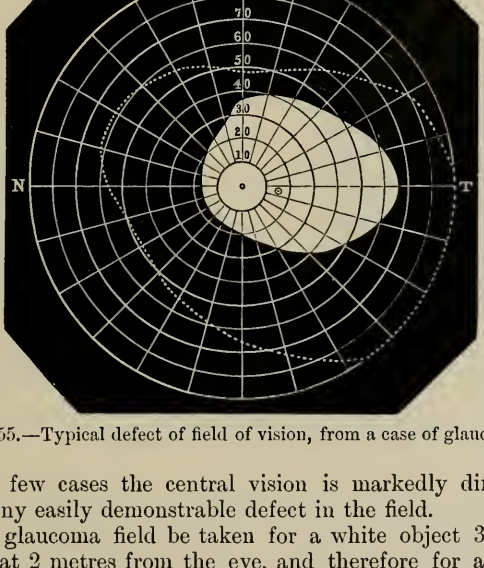


FIG. 155.—Typical defect of field of vision, from a case of glaucoma.

In not a few cases the central vision is markedly diminished without any easily demonstrable defect in the field.

If the glaucoma field be taken for a white object 3 mm. in diameter at 2 metres from the eye, and therefore for an object subtending a very small visual angle, there is almost invariably to be found a very characteristic form of restriction. The shape of the field is by no means always the same in all cases, but the defective area is always found to extend right up to the blind spot in one direction or another. The blind area corresponding to the entrance of the optic nerve is therefore continuous in some direction with the defect in the field caused by the glaucoma, while in other directions it is found to have its normal boundaries.

This symptom, first described by Bjerrum, is the earliest recognisable change in most cases of glaucoma. The peculiar form of restriction described is not met with in any other disease.

Photopsia, or the subjective sensation of light, is not an invariable symptom, and is besides a very inconstant one in any particular case of glaucoma. It is seldom very marked, but is sometimes present to a painful extent, and often persists even after the disease has led to complete blindness. Even at this time it is a variable symptom, being only experienced during the attacks which give rise to pain and increased tension. It is a very common thing to hear patients who are absolutely blind

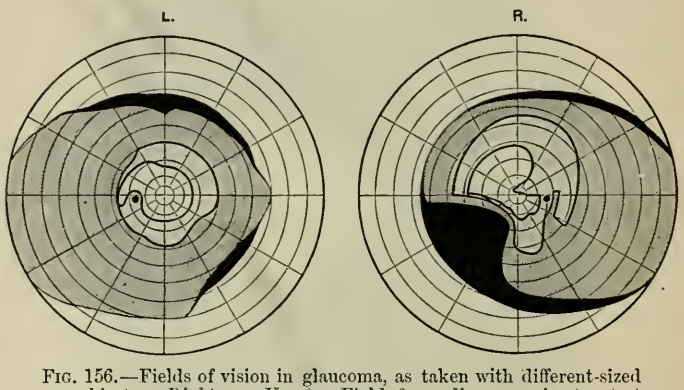


FIG. 156.—Fields of vision in glaucoma, as taken with different-sized objects. *Right eye*, V=$\frac{6}{36}$: Field for ordinary perimeter test ($\frac{1}{250}$) shaded area: for 3 mm. object at 1 metre ($\frac{3}{1000}$) dotted area: for 1 mm. object at 1 metre ($\frac{1}{1000}$) white area. *Left eye*, V=$\frac{6}{6}$: Field for $\frac{1}{250}$, shaded area: for $\frac{1}{1000}$, dotted area: for $\frac{1}{2000}$, white area.—From a case of Dr. Sinclair's.

from glaucoma declare that they can see light, and to find on examination no cause for this other than a mechanical one.

Anæsthesia of the cornea is met with in almost all cases of confirmed glaucoma. The anæsthesia is not as a rule equally marked over the whole extent of the cornea, but it is seldom that on careful exploration some point or points of diminished sensibility are not to be found. The test is best made by touching the cornea with a small feather or camel's-hair brush. The cause of this anæsthesia is probably explained by pressure on or separation of the nerve filaments in the cornea as a result of the œdema, which is the anatomical change giving rise to the haze.

Pain, varying in amount from a disagreeable sensation of fulness and dragging in the eye, to the most acute neuralgia

over the whole region supplied by the fifth nerve, is a symptom which always marks at anyrate the exacerbations in congestive glaucoma, and which in many cases is pretty constant. Unfortunately those who suffer from glaucoma do not, as a rule, get rid of the pain after the glaucoma has become absolute.

In very acute cases the irritation of the fifth nerve brings on somewhat alarming general symptoms,—feverishness, sickness, and vomiting,—which may be so severe as to distract attention from the local mischief.

The most common form in which glaucoma presents itself is as subacute attacks, following each other at intervals, the first beginning as a rule after some premonitory symptoms have previously been observed. After each attack of this nature a partial recovery of vision takes place, but the ultimate amount of vision is almost always less than it was before, the field more restricted, and the excavation of the papilla more marked. The exacerbations become eventually more frequent and permanent, and the recovery after each attack is less complete, until eventually the chronic congestive type of the disease is fully developed, and presents all, or most of, the objective and subjective symptoms already described. Even after a long continuance of the simple non-congestive form of the disease, it is possible for acute symptoms to develop all at once. As a rule, however, cases of glaucoma simplex retain their character to the end. Probably many years may pass before the excavation of the nerve becomes complete; but when the case is first seen, there is generally marked cupping, although there may be no external evidence of any impeded circulation.

In a severe acute attack the circulatory disturbance leads not only to rapid and extreme increase of intra-ocular tension, but also to exudations into the external tissues of the eye, giving rise to chemosis, and even redness and swelling of the lids. The corneal haze, too, is very great, the pupil dilated and absolutely immobile, while the severity of the attack is evidenced by the photophobia, lachrymation, pain, vomiting, and general disturbance to which it gives rise. The vision, too, is either rapidly altogether lost or very much impaired. A subacute attack, on the other hand, is characterised by a less sudden deterioration as well as by a greater subsequent improvement of vision.

Acute or subacute attacks of glaucoma come on in eyes predisposed to the disease after the occurrence of anything which may be supposed to lead to a venous stasis in the uveal tract, either directly or owing to diminished arterial tension. Fits of mental depression and sleeplessness are thus likely to be followed

by glaucoma, and this is also the case where there is a weakness of the heart's action, as during convalescence from illness. In short, any debilitating condition may be followed by glaucoma. Under such circumstances the pupil is apt to become dilated. This condition is of itself likely to favour the outbreak of glaucoma when the predisposition exists. Thus one sees every now and then an attack follow the use of atropine. Even homatropine and cocaine have been observed to produce the same effect. On the other hand, a natural or induced contraction of the pupil, when this can take place, often cuts short an attack. This is no doubt one reason why sleep is found to be so beneficial in the early stage of the disease. As to the *predisposition*, it is seldom, unless premonitory symptoms have been complained of, that one can be alive to its existence.

Diagnosis.—There are two reasons why an early diagnosis of glaucoma is desirable. On the one hand, it enables one to treat the disease at a stage when, according to the severity of the glaucoma, little, or comparatively little, permanent damage has been done to sight; and, on the other hand, at which, altogether independent of this, it is most amenable to treatment. Except in cases of the more acute congestive variety of glaucoma, the result of successful interference is only a checking of the disease, without restoration of what has been lost.

Whilst, then, these considerations suffice to show the importance of making a diagnosis, it must be admitted that the diagnosis is by no means always easy. In acute congestive attacks, the more or less marked symptoms of general disturbance are apt to take one's attention from their real point of origin. In non-congestive glaucoma, on the other hand, the disease is usually of a slow, insidious nature, and as such is apt to escape observation. Indeed, there are some cases of the so-called "simple" variety of glaucoma which even the experienced ophthalmic surgeon may have great difficulty in distinguishing from cases of atrophy of the optic nerve.

The general practitioner, who has not devoted very considerable attention to the clinical study of eye diseases, could hardly be expected always to diagnose glaucoma. He should, however, unquestionably know of the existence of such a disease, and, in the absence of any particular familiarity with it, it would be well if he erred rather on the side of too great than of too little suspicion of its presence, in cases the exact nature of which he did not understand. Thus, especially in elderly or old people who may complain to him of failing sight, he should always inquire as to the particular subjective symptoms which may

characterise that failure. More particularly should he ascertain if there appears to be any more or less marked degree of intermittency in it. Are there, for instance, periods of greater obscuration, succeeded by longer periods of relatively better vision? Further, is there a more or less constant haze or smoky veil seen in front of the eyes, which occasionally appears to be denser than at other times? Temporary obscurations, clouded or misty vision, and the appearance of coloured haloes or rings round lights, are suggestive of glaucoma, particularly in old people, and should awaken suspicion. It must be remembered, too, that these symptoms are not always very marked in the "simple" cases of the disease.

Therefore, in the presence of failing sight, which is only, it may be, subject to periodic variations, a very easy examination should be undertaken. This consists of a rough test of the scope of the field of vision in the manner described in Chap. II. Any restriction, particularly if it involves the lower or inner portions of the field, should awaken the suspicion of glaucoma. Great failure of vision, without any restriction in the scope of the field of vision, is rare in glaucoma. Under the circumstances, then, a free, unrestricted field of vision should be reassuring where there might otherwise have appeared to be any reason to suspect glaucoma. On the other hand, the opposite condition, namely, restriction of the field with comparatively little loss of vision, should strengthen such suspicion.

I have referred, so far, to subjective symptoms and subjective examination in this relation, because experience has taught me that fewer mistakes are liable to be made by the comparatively speaking inexperienced, than when attention is directed more to real or imaginary objective signs. Such objective signs there are, as we have seen. Indeed, the diagnosis cannot properly be confirmed without giving attention to them as well. In the order of their importance these signs are: excavation or "cupping" of the optic disc, increased intra-ocular tension, haziness of the cornea, semi-dilatation of the pupil, and enlargement of the episcleral veins.

Now, with regard to these, it may be said that if the general practitioner, who so comparatively seldom meets with a case of glaucoma at all, and who has so many other diseases to know about and to treat, is to wait till he can satisfy himself of the existence of a "glaucoma cup" before feeling reasonably satisfied that he has to do with a case of this disease, he will, generally speaking, fail to act in the best interests of his patient. There are, in fact, some cases in which a certain degree of doubt may

exist as to whether a particular excavation is essentially "glaucomatous" or not. Then, as to increased tension, it is often, in the more chronic cases, difficult to feel satisfied that there is any abnormal degree of tension present. Like other signs of glaucoma, the increased tension is to a great extent an intermittent one. Nevertheless it is one of the most important signs to which to direct one's attention in the less frequent variety of congestive glaucoma, with pain and corneal haze.

I have found that the cases of glaucoma most liable to be overlooked by the patient's ordinary medical attendant are the chronic non-congestive ones, and the very acute congestive attacks associated with marked general disturbance. The first class of case, especially when occurring, as it usually does, in an old person, is apt, in the absence of a properly directed subjective examination, to be mistaken for cataract. The greyish reflection which comes from the lens in old people gives rise, when the pupil is more or less dilated, to the idea that there is an actual loss of transparency of the lens. The patient is then told that he has cataract, and that nothing can be done until he has become blind. Thus the opportunity for arresting the disease is lost. A knowledge of the existence of such a disease as glaucoma, and of the various forms which it may assume, and a simple subjective examination on the lines above referred to, would strengthen the suspicion that a mistake in diagnosis might be possible, even should the ophthalmoscopic signs of cataract not be looked for.

In acute glaucoma, with general disturbance, it must be admitted that a mistaken diagnosis is more natural. The cases themselves are of rare occurrence, and the period, moreover, during which it might be possible to adopt a satisfactory line of treatment is much shorter. The pain in the eye and the accompanying blindness, though caused by the same excessive tension which gives rise to gastric pain and vomiting, is generally disregarded even by the patient himself. He is more inconvenienced by the general disturbance, and his medical attendant treats him for the acute gastric symptoms, and overlooks their cause. Such a mistake is not likely to occur twice to the same practitioner, yet it is one which in my experience is not infrequent. For this reason it should be remembered that violent gastric attacks may be set up in this way, and that if there be pain in one eye, preceding or accompanying such attacks, the tension of the eye should be felt and the eye examined. The tension in the case of an acute glaucoma, giving rise to symptoms of this degree of severity, will be found to be greatly increased. It is easy to

satisfy one's-self that the eye is "stony" hard. An inspection of the eye shows it to be congested, with the cornea steamy and the pupil dilated.

The diagnosis is most difficult in the case of the simple form of the disease, and here sometimes the difficulty is very great. In all cases the form of excavation of the papilla, the presence of arterial pulsation, more or less irregularity of the pupil, fulness of the episcleral veins, anæsthesia of the cornea, and the condition of the colour and light senses, are the points to which attention must be given, or which must be looked for. It must be remembered that an evident increase of tension may be absent at the time of examination.

It is with some forms of atrophy of the optic nerve that one is apt to confound glaucoma simplex; and, further, there is often great difficulty, where the glaucoma exists along with myopia from choroidal disease, in satisfying one's-self as to its presence. When the data afforded by the objective appearances are not sufficient to justify a diagnosis, and when no very characteristic restriction of the field of vision exists, great help may be obtained by an examination into the state of the field of vision by Bjerrum's method, which in my experience is by far the most delicate subjective test. The light sense should also be tested. In cases of pure atrophy, *i.e.*, such in which the nerve elements of the retina are primarily involved in the process which gives rise to the amblyopia, it is found that while very little more amblyopia is caused by reducing the illumination, and the minimum perceptible amount of light is not markedly less than normal, a very distinct defect exists in the ability to distinguish between different intensities of illumination. On the other hand, the choroido-retinal affections exhibit exactly the opposite conditions with respect to these two elements of the light sense, namely, more or less marked night blindness, with relatively good power of distinguishing between different intensities of illumination. In glaucoma the defects in the light sense occupy an intermediate position, though considerable differences exist in this respect.

Secondary glaucoma.—Much the same set of symptoms, and occurring with different degrees of severity, are to be found in eyes which are the site of other affections, either inflammatory or traumatic. There is then said to be secondary glaucoma, as the glaucomatous symptoms have not originated of themselves, but have followed upon some change which of itself is recognised as pathological. When the condition of secondary glaucoma is set up, the risk which the eye runs is the same as when

the disease is primary. In many cases the cause of the circulatory disturbance is apparent, of a more or less distinctly mechanical nature, and, as it were, less intimately associated with the symptoms to which it gives rise. Often the cause can be removed. Thus glaucoma, along with iritis or traumatic cataract, can generally be arrested by operation. This is not generally the case, however, when the cause is a dislocated lens, or a dense leucoma adherens, leading to staphyloma.

One form of secondary glaucoma deserves special attention, namely, what is called *hæmorrhagic glaucoma*. In this disease glaucomatous symptoms of varying intensity supervene, generally after the lapse of some weeks, upon an attack of apoplexy of the retina. The pain is usually very great in such cases, and the condition may occur in one or both eyes, though fortunately more frequently in one alone. There is often a history of sudden blindness coming on before the attack of the glaucoma. The iris may present the appearance of hæmorrhagic infiltration, or there may be blood in the anterior chamber. The chamber itself is never shallowed in the manner so characteristic of primary glaucoma. The individuals in whom hæmorrhagic glaucoma occurs are almost always advanced in life, and the subjects of atheromatous degeneration of vessels. They not infrequently die of cerebral apoplexy.

A pretty distinct group of cases, complicated by increased intra-ocular tension and other symptoms of a glaucomatous state, are those in which for some cause or other there is an abnormal degree of exudation passing from the iris or ciliary processes, as in serous irido-cyclitis. Other forms of iritis may become complicated by secondary glaucoma probably from another cause, namely, an interference with the escape of the aqueous from the posterior into the anterior chamber, which results from the existence of total posterior synechiæ; and when secondary glaucoma, owing to this condition, is present, one sees a more or less marked bulging forward of the iris.

Traumatic cataract, whether produced accidentally or by operation, is not infrequently followed by increased tension. Two conditions appear to give rise to this, namely, the swelling of the lens substance within its capsule, and the filling of the anterior chamber with the broken-up portions of the lens. The latter is more likely to cause this complication the greater the mass of lens matter occupying the anterior chamber, and the older the individual in whom the trauma has occurred.

Dislocation of the lens is another cause of secondary glaucoma. Intra-ocular tumours almost invariably, when they have attained

any size, give rise to glaucomatous symptoms, which are sometimes so severe as to render the diagnosis of the primary disease very difficult, owing to the haziness of the dioptric media.

Whilst primary glaucoma is almost exclusively a disease occurring late in life, secondary glaucoma is met with at all ages, although undoubtedly more is required to set it up in young eyes than in old. The vision, too, does not appear to be so rapidly or permanently interfered with by the increased tension in young eyes.

Two important forms of complicated glaucoma occur—(1) Cataract with glaucoma; (2) high myopia with glaucoma. Both conditions are fortunately rare.

Sometimes one meets with glaucoma after extraction, *i.e.*, in an aphakic eye. Glaucoma may also come on after needling for after-cataract. It is then due to cyclitis.

Glaucoma in a highly myopic eye is, properly speaking, secondary, inasmuch as the choroidal changes which lead to the elongation of the globe probably interfere at the same time with the circulation in that membrane, and lead to a glaucomatous complication. From a clinical point of view, it is better to look upon the form as a complicated glaucoma. The tension is rarely very high, though above normal; the field of vision becomes restricted in a manner more or less characteristic of glaucoma, and the papilla is excavated. It is the excavation of the papilla, as well as sometimes the unusual amount of pain complained of, which should lead one to suspect this complication. The excavation is never so deep as in other forms of glaucoma, but it is unmistakable whenever it is seen to reach out to the margin of the papilla. In these cases there is always a very marked and often excessive degree of choroidal atrophy surrounding the papilla.

Prognosis.—The prognosis in glaucoma, in whatever form the disease may present itself, is always bad whenever the glaucoma has begun to produce an impairment of vision. The premonitory stage may exist for a long time, and may even never lead to confirmed glaucoma. It is rare, if indeed it ever happens, that the disease becomes spontaneously arrested; so that, for practical purposes, we must consider that glaucoma, left to take its own course, invariably leads sooner or later to total destruction of vision.

When an operation is performed, the prognosis may be said to depend on the stage of the disease at which it is undertaken, on the nature of the operation, on the manner in which the operation has been performed, and the way in which healing

has taken place. Not a little depends, too, on the form of disease treated, and the presence or absence of complications.

The *treatment* of glaucoma should differ according to the stage of the disease. Where only occasional premonitory symptoms are present, and vision is therefore good during the intervals, there may be a reluctance on the part of the patient to undergo an operation. The local application of a miotic may then be adopted. A half per cent. solution of nitrate of pilocarpine dropped into the conjunctival sac speedily cuts short these attacks. At the same time attention should be directed to the general health, and, if the heart's action be weak, iron and digitalis prescribed. A properly performed iridectomy at this stage, not only checks the premonitory attacks, but almost certainly prevents the progress of the disease altogether. There should, therefore, be no hesitation in proposing an iridectomy even at the early stage, and all the more urgently if the symptoms frequently make their appearance, as it is impossible to say how much damage may be done, and done irretrievably, as soon as the disease becomes confirmed.

Unquestionably, however, as soon as the glaucoma has begun to interfere permanently with the function of the eye an iridectomy should be performed.

Iridectomy is the only cure for glaucoma, and is the more likely to be successful the more the iris tissue has retained its normal character. When atrophic changes have begun, much depends upon their extent whether removal of a portion of iris will be sufficient or not to permanently arrest the glaucoma. In all cases the iris should be cut as peripherally as possible, but should not be detached from its ciliary attachment. Great care should be taken to prevent any portion of the iris becoming entangled in the wound. This encleisis of the iris is very apt to interfere with the effect of the operation, as the iris is not only dragged upon, but prevents the firm close healing of the external wound which should be aimed at.

The first effect of an iridectomy for glaucoma is generally to reduce the tension of the eye. Where it does not do so, the prognosis is mostly, though by no means always, unfavourable. The reduction of the tension very soon relieves the pain which may have existed. In acute cases, where the cornea has been very hazy, the rapid disappearance of the œdema, to which the haziness is due, admits of considerable improvement of vision, though this may be marred by blood effused from the cut surface of the iris. Bleeding from the iris is not uncommon, and may take place at the time of the operation, or several days afterwards.

In acute cases there may be added to the improvement of vision, due to the clearing of the cornea, a further improvement, which results from the circulation in the uveal tract assuming a more normal character. Two or three weeks, or even longer, often elapse before the restoration of vision has reached the full amount possible. In subacute and chronic cases the same amount of improvement of vision is not to be expected, and the operation will have served its purpose if the vision existing at the time of its performance is retained.

Often, indeed, in the case of simple glaucoma, iridectomy, although arresting the progress of the disease, leads immediately to some deterioration of vision, and this is more especially evident in the peripheral vision, the field of vision being not infrequently found to be narrower after than immediately before operation. It is well to remember this, as it sometimes happens that in cases where the nasal portion of the field is restricted to nearly the point of fixation, that point becomes itself included in the blinded area by the slight increase in the restriction following the operation, and the vision thereby rendered all at once very much worse. In more acute cases of glaucoma the previous use of a miotic not only facilitates the performance of the iridectomy, but renders the accidents, which may occur on the sudden reduction of the tension, less liable. It is well, too, in operating for acute glaucoma in one eye, when the other has so far exhibited no signs of the disease, to keep the sound one under the influence of a miotic, as the mental anxiety of having to submit to an operation has not infrequently been observed to induce an attack of glaucoma in the hitherto sound one.

In the true hæmorrhagic glaucoma, iridectomy almost certainly leads to further hæmorrhage and rapid destruction of vision. In such cases, therefore, the operation is on the whole contra-indicated.

In some of the cases of simple glaucoma, in which the tension is not diminished immediately after the operation, rapid loss of sight takes place. To these cases the name of *malignant glaucoma* has been given. Sometimes the cause of this is a subretinal hæmorrhage. Usually, however, there is a forward displacement of the lens, leading to a blocking of the channels for the escape of liquids at the angle of the anterior chamber. In these cases the proper treatment is to extract the lens.

Even when iridectomy fails to arrest the progress of the blindness, it generally protects the eye against the occurrence or recurrence of a congestive attack of glaucoma. Iridectomy is not only capable of reducing tension, but of regulating it to

a certain extent; so that when performed for cases of chronic irido-cyclitis, in which diminution of tension has taken place, it often leads to a more normal tension; therefore, instead of reducing, it actually increases the hardness of the eye. Whatever be the nature, then, of the curative action of iridectomy in glaucoma, it is certain that it does more than merely reduce tension. In some way or other it also induces a more normal condition of the circulation in the uveal tract.

In cases of acute congestive glaucoma, the first thing to be done is to give a subcutaneous injection of morphine. Then, as soon as possible, preparations must be made for the operation of iridectomy. Owing to the great pain which this operation causes in such cases, it should be performed under chloroform. It is otherwise very difficult, even when there is enough assistance at hand, to keep the patient sufficiently quiet.

Fig. 157.—Keratome.

Iridectomy.—The instruments required for iridectomy are—a spring speculum, a pair of fixation forceps, a bent triangular lance-shaped knife (often called a keratome, Fig. 157), a pair of iris forceps, or iris hook (Tyrrell's hook), a pair of iris scissors, and a small flexible caoutchouc or tortoise-shell spud.

In making the necessary section with the keratome, the operator may either push the point away from him or towards him; in performing an iridectomy upwards, therefore, he will in the first case stand behind the patient's head, and in the second at the side of the patient, and at the same time as much in front of him as possible. When there is plenty of room,—that is to say, where there is a good anterior chamber,—either manner of introducing the knife is equally easy. In introducing the knife, however, into a narrow chamber, the second is perhaps the better, as it enables the operator to watch the point much more closely. After the eye has been cocainised, and the conjunctival sac well washed out with the corrosive sublimate solution, the speculum is introduced, and the surgeon, taking the fixation forceps in the left hand, takes a firm hold of the conjunctiva and subconjunctival tissue close up to the cornea at the opposite end of the diameter in which he intends to make the iridectomy. The knife should then be introduced at the

corneo-scleral margin, the point being directed at right angles to the surface in that situation, and pushed forwards until it has just pierced the thickness of the cornea. It is then directed more forwards by depressing the handle, and, with the plane of the blade parallel with the iris, pushed rapidly *and without any hesitation* on into the anterior chamber. The blade is then *slowly* withdrawn, with the point tilted slightly more forwards.

Tyrrell's hook, or the iris forceps, is then introduced into the anterior chamber. Personally I always use the hook, except in cases where the iris is much tied down by adhesions. The hook should be of platinum, so that it can readily be bent into any shape required. The point should be blunt and perfectly smooth. It is introduced with the hooked end on the flat, passed inwards parallel with the iris, but without touching it, until its end has got beyond the edge of the pupil; a slight rotation is then given to the instrument, so as to direct its point towards the lens, and it is slowly withdrawn until it catches well on to the pupillary margin. The iris can then be dragged out of the wound, with the hook kept as flat as is consistent with its retaining a good hold of it. It should be slowly dragged out, and without any great traction, and then snipped off with the scissors. With a good assistant it is better for the operator to entrust the scissors to him and maintain fixation himself, with the forceps held in the other hand. Various forms of iris scissors are in use.

When the iris forceps is used, it should be introduced closed, until the points lie just over the margin of the pupil, when they are allowed to open, and are at the same time pressed gently down upon the iris. In this way a portion of the iris, including a portion of the pupillary margin, rises in between the two limbs of the forceps, which are then firmly closed and slowly withdrawn, until a good snip can be got with the scissors outside the wound, which leaves a piece of detached iris in the forceps. A stream of sublimate lotion may now be poured upon the wound. The eye is then closed and gentle friction made over the lid; in this way any part of the iris caught in the wound is as a rule liberated; but if the iris should not have returned to its place, it may be gently dragged away, by passing the caoutchouc spud into the angles of the wound and on to the surface of the iris. This must only be done, and with great care, when the first proceeding fails. If there is any bleeding, the upper lip of the wound should be slightly depressed, so as to permit of its escape; but attempts to remove blood should not be persisted in for any length of time. The bleeding usually comes from the conjunctiva, a portion of which may have been snipped off along

with the iris. Care should therefore be taken, in using the scissors, to see that only iris is included between its blades.

With regard to the performance of iridectomy for glaucoma, the incision made into the anterior chamber should be a peripheral one, and be made with a thoroughly sharp knife. There is a tendency with some operators to attempt a more peripheral section than can be easily made. They thus render the operation not only more difficult, but less likely to check the glaucoma. A sufficiently peripheral section is most efficiently made with the triangular bent keratome, which should be rapidly introduced and then slowly withdrawn. Occasionally, owing to the eye being deeply sunk, the manipulation of this knife is a matter of difficulty. A Graefe knife may then be used, and the section made by puncture and counterpuncture, cutting afterwards as peripherally as possible from within outwards, and preferably in one sweep—that is, without any sawing motion. It is seldom that this section is as satisfactory as one made with a keratome. Cutting thus from within outwards necessarily, to some extent at least, entails a wounding of the peripheral portions of the iris which lie nearest the corneal wound.

It used to be a rule to remove a large portion of iris. In my experience, a coloboma of 4 or 5 mm. diameter is sufficient. Nor is it necessary, as is sometimes advised, to forcibly tear the piece of iris excised from its peripheral attachment. On the contrary, this may in some cases do harm. Large iridectomies are necessary in cases of closed pupil from iritis. In glaucoma a moderate-sized coloboma and a large and peripheral corneoscleral section, which should, however, preferably not entail the very apex of the angle of the anterior chamber (though this is usually recommended), and which should be made with a keratome, is what should be aimed at.

The cases that do best are those in which the section heals quickly, leaving a barely visible scar. The bulging of the cicatrix, or a cystoid character of the union of the lips of the wound, is an indication that the operation has failed to fully relieve the increased tension. And although a cicatrix of this kind may act as a sort of safety-valve for a longer or shorter time, the condition of an eye in which it occurs cannot well be looked upon as quite satisfactory. Some surgeons, however, attach importance to the cystoid scar, and go so far as to look upon it as even desirable.

For some time after the performance of iridectomy for glaucoma, it is a good precaution to drop a solution of eserine or pilocarpine into the eye two or three times daily. The amount

used may gradually be diminished to one instillation daily, one every second day, and so on, when careful examination of the tension and the visual acuity shows that no recurrence has taken place.

An iridectomy which has been properly performed, and which has temporarily checked the disease, seldom fails to effect a permanent relief. This may, however, happen, and is then due to one of two causes. Either the increased tension returns after some time (it may be with the consolidation of the cicatrix at the corneal margin), or a slow degenerative change in the retina causes blindness. The former seems to be the more common cause, and the question then naturally arises whether any further operation is called for, and if so, what. No doubt, in respect to such cases, there may be some considerable difference of opinion, even amongst those whose practical experience is sufficiently extensive to entitle them to hold some view on the matter. It is difficult, perhaps, in such a case not to be influenced by theoretical views as to the conditions giving rise to increased tension. I have found however, practically, that the treatment most likely to lead to a good result is to reopen the old corneal scar, and at the same time make a fresh wound and remove a further portion of iris. This operation is best done with a Graefe knife, which, being entered at the corneo-scleral margin at some distance from one end of the old scar, is passed out of the chamber at or near the other end of the scar, and the section completed by cutting outwards. A portion of iris continuous with one limb of the existing coloboma is then removed, and thus the coloboma made larger. Von Graefe's plan of making an altogether fresh iridectomy directly opposite to the first one is no doubt also effective, but has the disadvantage of causing a greater disfigurement.

When the cause of deterioration after operation is the second one mentioned, no further operative interference is called for. The cases in which this result is mostly met with are in my experience those in which the central vision has from the first been relatively more impaired than the peripheral. Probably, indeed, in such cases the increased tension, which in any case has been comparatively slight, is also of subordinate importance in the process which leads to progressive blindness.

Iridectomy has so far proved to be the most efficient means of checking glaucoma, whether of the congestive or non-congestive variety. At one time sclerotomy was by many substituted for iridectomy, on the assumption that the beneficial action of the iridectomy depended entirely upon the incision made along the angle of the anterior chamber. There are still some surgeons who

apparently adhere to the practice of sclerotomy alone. Many, however, have returned to iridectomy, which from purely practical considerations they have found to give more permanent results.

The curative action of iridectomy in glaucoma has never received a satisfactory explanation. While capable of arresting both the acute and chronic forms of glaucoma, it is generally supposed to be more effectual in the former. This may, however, possibly depend upon its being performed, as a rule, in an earlier stage relatively, where the symptoms are acute. The action of iridectomy in glaucoma appears to be intimately connected with, if not entirely dependent upon, the influence which it has in permanently reducing the abnormal degree of intra-ocular tension.

It does this, probably, in three different ways, which may or may not mutually supplement each other. In the first place, the disturbed balance between transudation and excretion of aqueous, which leads to tension, may be given time for readjustment, by the escape of the liquid through the wound before healing takes place; and subsequently the normal main channel for excretion, at the angle of the anterior chamber, may suffice. Or, again, the absorption which takes place normally by the vessels of the iris—the circulation in which is materially altered by the excision of a portion of that membrane—may be increased, and thus more efficiently supplement the excretion by the main channel. Lastly, and least satisfactorily, the "safety valve" of a cystoid cicatrix may amount to an additional excretory channel. In accordance with this view of the action of the cut iris, it is found that iridectomy is the more efficient the more normal is the structure of the iris at the time of operation. On the other hand, an atrophic condition of the iris weakens the chance of a satisfactory result from iridectomy. The operation is then often followed by the formation of a cystoid scar.

CHAPTER XIV.

INTRA-OCULAR TUMOURS.

Sarcoma of the choroid and ciliary body.—Sarcoma of the choroid is usually circumscribed, but occasionally occurs as a diffuse infiltration. It may be either pigmented or not. The pigmented cases are much the more common.

Of 259 cases of sarcoma met with by different observers, the records of which have been collected by Fuchs, sixteen, or 6 per cent., occurred in the iris, twenty-two, or 9 per cent., in the ciliary body, and 221, or 85 per cent., in the choroid. Of the twenty-two occurring in the ciliary body, twenty were pigmented. Of the choroidal cases, 196 were pigmented and twenty-five unpigmented.

The most common point of origin for sarcomata of the choroid is at or near the posterior pole of the eye, a little to the outer side of the disc. They take their origin from the layer of big vessels. After the tumour has grown to a certain size in the eye, it perforates the coats and extends outside of it. The sclera is most frequently perforated; sometimes also the cornea and the optic nerve. Perforation through the sclera takes place at the corneo-scleral margin or in the vicinity of the optic nerve, or sometimes at other parts where it is weakened by the passage of vessels through it into the eye. Often, owing to the resistance offered by the sclera, the band of connection between the intra- and extra-ocular portions of the tumour is very small, but more and more of the sclera is usually destroyed as the tumour increases in size, which it may do if left alone until it has attained very considerable dimensions—as large as the closed fist, or even larger. Notwithstanding such an increase in size, the bones of the orbit are very rarely involved.

The lymph glands in the neighbourhood of the eye are never affected in cases of uveal sarcoma. The tendency to metastasis is, however, very great, as it is by the blood that the tumour elements are carried to a distance. The more vascular the tumour,

the thinner and larger its vessels; and the softer the new tissue, the more likely is this to happen, and therefore the greater is the malignity of the growth.

When the sarcoma grows from the ciliary body, it grows forward into the posterior or anterior aqueous chambers, as well as backwards into the vitreous. It may thus become visible, on simple inspection of the eye, before it attains any very great size. A tumour in this situation occasionally sets up severe irido-cyclitis, by which the diagnosis may at first be rendered difficult. Tumours which take their origin farther back detach the retina in front of them. At first the portion detached lies immediately over the tumour, and it is often difficult, from ophthalmoscopic examination alone, to tell whether the detachment is simple or produced in this way. The defect of the field of vision is, in the case of tumour, as a rule sharply defined. There may also be relatively better central vision, when the site of the growth is peripheral, than is generally to be found in simple detachment. The tension of the eye is also an important guide to the differential diagnosis. It is most frequently increased in the case of a tumour; most frequently diminished when the detachment is idiopathic. After the tumour has existed for some time and increased in size, the whole retina gradually becomes detached, and assumes the funnel or convolvulus-shaped form which is characteristic of complete detachment. Uveal sarcoma occurs about equally frequently in both sexes, and is for the most part a disease of advanced life. Only eleven out of 259 cases collected by Fuchs occurred before the age of 10, only twenty-seven before the age of 20. It is very rarely bilateral.

The course of the disease is generally divided into four stages —(1) The quiescent or non-irritative stage; (2) the irritative or inflammatory stage; (3) the extra-ocular stage; and (4) the metastatic stage.

The average duration of the *first stage* is from eighteen to twenty-one months, the lower limit being for cases of sarcoma of the ciliary body, the higher for those of the choroid proper. Usually at the first examination a brownish or yellowish protuberance is seen, on which, when the retina is not too intransparent, an indistinct and irregular network of vessels may be made out lying behind the retinal vessels. Anteriorly situated growths may sometimes be made out very distinctly by oblique illumination, if the pupil be well dilated with atropine.

In the *second stage* the eye is painful, and the tension more or less markedly increased. Often the condition presents much

the appearance of congestive glaucoma. From the idiopathic or primary form of that disease, it is recognised mainly by the absence of any periods of remission, which constantly occur in true glaucoma. When set up by a tumour, the inflammation and increased tension is usually constant. The duration of the second stage is less than of the first—on the average not longer than a year, and often considerably less.

The *third stage* is entered upon by the tumour perforating and growing externally. The growth then becomes very rapid as a rule, and ulceration, accompanied by a purulent discharge, takes place on its surface. The pain at this stage often considerably abates at first, but reappears as a rule when proptosis, owing to extension of the tumour to the orbit or lids, becomes marked.

As to the *fourth and final stage*, all that can be determined with any certainty is the period at which metastasis, which most commonly occurs in the liver, reveals itself by the appearance of symptoms. The tumour growth may of course begin, and in many cases no doubt has begun, long before it gives rise to any symptoms.

Diagnosis.—The chief difficulty of diagnosis presenting itself during the first stage is to distinguish a choroidal sarcoma from idiopathic detachment of the retina. Sometimes, in the case of tumours, there is a circumscribed enlargement of the episcleral vessels over the region of the detachment. This is caused by blocking of one or more of the venæ vorticosæ by the growth. The other points to be attended to in the differential diagnosis have already been explained. Detachment of the choroid might be mistaken for sarcoma, but the suddenness of onset and the diminished tension would be significant.

In the second stage of sarcoma a confusion with idiopathic congestive glaucoma might be made, although such a mistake ought to be uncommon if proper attention be paid to all the circumstances connected with each case. In glaucoma the vision has usually been good before congestive symptoms have set in; there have, besides, often been observed the characteristic premonitory symptoms. There is, besides, the constant tendency to intermittence in the pain, and in the increased intraocular tension, so characteristic of that affection. When the glaucoma is absolute in the one eye, there are often symptoms of the disease already existing in the other. In the case of sarcoma, on the other hand, the patient has usually been conscious of more or less blindness of the eye before it becomes painful. When the congestive symptoms set in, they are constant. A

brightish reflection from the completely detached retina can often be seen. Both eyes are hardly ever affected at the same time.

In cases where the choroidal tumour gives rise to irido-cyclitis, the diagnosis may certainly be rendered difficult, and still more so when shrinking of the globe takes place as the result of this inflammation, as sometimes happens. In idiopathic irido-cyclitis the sight has probably been good before the onset of the inflammation, and is only slowly lost as its progresses. It often, too, affects both eyes. The shrunken eye resulting from simple irido-choroiditis is usually painful on pressure, but seldom subject to any great spontaneous pain, which, on the other hand, characterises that which encloses a tumour.

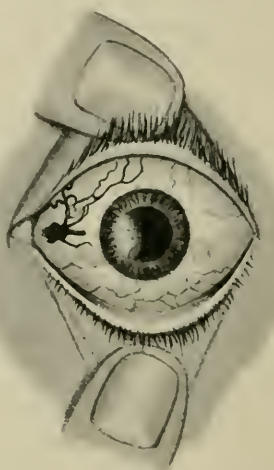


Fig. 158.—Case of sarcoma of the choroid, showing greatly engorged episcleral vessels and tumour as seen by oblique illumination.

The *prognosis* in uveal sarcoma, if an operation be not undertaken, is as bad as possible. The disease is probably invariably fatal, and the time the patient has to live from its first appearance is not much more than five years, and often considerably less.

Of the cases on which Fuchs founded his statistics, 285 were operated on, and of these thirty-one, or 13 per cent., were followed by local recurrence of the growth. In most of the cases recurrence took place within a year. Statistics show that if recurrence does not take place within four years after removal of the eye, it is not likely ever to make its appearance.

The following table, taken from Fuchs' work on sarcoma, shows well the influence which the stage at which the operation is performed has on the liability to recurrence :—

Stage.	Total Cases.	Recurrence.	Recurrence Percentage.
I. . . .	21	0	0
II. . . .	97	5	5
III. . . .	117	26	22

It is evident, therefore, as might well be supposed, that the

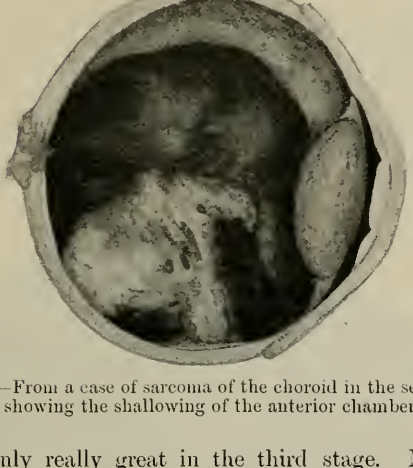


FIG. 159.—From a case of sarcoma of the choroid in the second stage, showing the shallowing of the anterior chamber.

danger is only really great in the third stage. Metastasis is, however, ever so much more common, and constitutes the real source of danger. There are no statistics, so far as I am aware, which give any idea as to the frequency of metastasis; but the proportion of cases where the patient has been known to be alive five years afterwards is not very great. My own experience, however, leads me to believe that it is considerably greater than used to be generally supposed. One curious and important point brought out by Fuchs' statistics is that metastasis appears just as likely to take place if the operation is done in the first

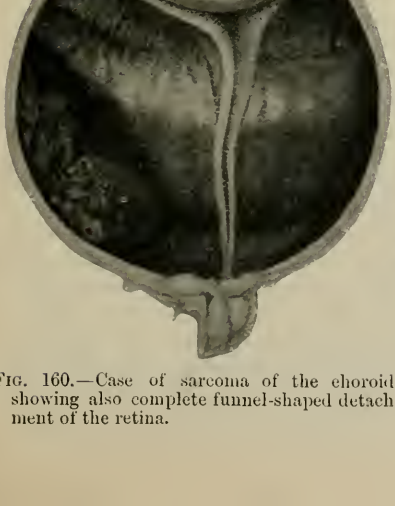


FIG. 160.—Case of sarcoma of the choroid, showing also complete funnel-shaped detachment of the retina.

as in the third stage. Leber, on the other hand, found it less likely to occur if the primary growth were removed in the first stage.

The only possible *treatment* is to remove the eye. This should be done as soon as the diagnosis is certain. In the later stages, when the orbital tissues are invaded, the whole contents of the orbit must also be removed.

Metastatic carcinoma of the choroid has been described. It seems always to occur in both eyes, and usually after carcinoma of the mamma.

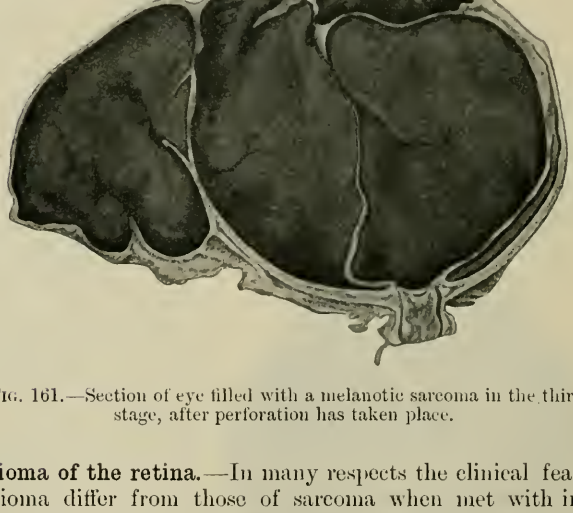


Fig. 161.—Section of eye filled with a melanotic sarcoma in the third stage, after perforation has taken place.

Glioma of the retina.—In many respects the clinical features of glioma differ from those of sarcoma when met with in the eye. Glioma shows even a more marked tendency to undergo degenerative changes than sarcoma. These may be fatty, calcareous, cheesy, and pigmentary, the first being the most common. As the mass grows, it causes a disappearance of the vitreous, and often a loss of transparency of the lens, which, along with the iris, is pressed forwards, causing shallowing of the anterior chamber.

After existing for some time in the retina alone, the choroid and optic nerve become involved in the tumour growth. The growth at first occupies mainly the medullary portion of the nerve, and only after involving this portion for some time

spreads to its sheath. This causes in many cases an immense thickening of the nerve, and it is for the most part in this way that extension first takes place to the brain. It is, as a rule, the extension to the brain that causes the death of the patient. Metastasis does occur; but far from being an invariable occurrence, as in sarcoma of the uveal tract, it is comparatively rare. Metastatic glioma has been mostly found in the liver, but has also been met with in the bones, ovaries, kidneys, and lungs.

Instead, then, of four stages which can be distinguished in the clinical history of sarcoma, only three characterise glioma—(1) The quiescent or non-irritative stage; (2) the irritative or glaucomatous stage; and (3) the stage of extra-ocular growth.

Blindness is a very early symptom of the *first stage*. It is only comparatively rarely, however, that this symptom directs attention to the disease, as such a large proportion of cases occur in infants, who do not complain until they begin to suffer pain. Often before this the parents observe a peculiar whitish reflection from the eye. This appearance and the accompanying dilatation of the pupil lead to the detection of the disease, often long after its first onset.

Owing greatly to the yielding of the sclera, glaucomatous symptoms, or those of the *second stage*, are delayed until a time when the tumour is much larger than a sarcoma, when it passes from the quiescent to the irritative stage. Children are therefore often first brought to the surgeon when there is already a good deal of increase in the size of the globe, and, what is worse, when the nerve has to a great extent been involved in the tumour growth.

The *third stage*, or the extra-ocular growth, is ushered in by the perforation usually of the cornea—sometimes, though much more rarely, of the sclera. As soon as the tumour becomes extra-ocular, it grows with great rapidity, involving the tissues of the orbit, of the temporal fossa, of the cheek, and even of surrounding tissues. The lymph glands in the neighbourhood are sometimes affected, but more frequently not. There can be little doubt that when metastasis does take place, it is brought about by absorption of particles of the tumour into the blood, and not by transmission through the lymph channels.

Occasionally it happens, just as with sarcoma, that an iridocyclitis is set up, and this may lead to shrinking of the eye. Whether or not shrinking takes place, the supervention of an inflammatory attack of this nature introduces a difficulty in the *diagnosis*.

That form of purulent choroiditis which is met with along

with cerebro-spinal meningitis is the disease most likely to be confounded with glioma. The differential diagnosis will depend partly on the history, and partly on the local appearances. In the case of choroiditis there will usually be a distinct history of an illness—fever, drowsiness, and other more or less marked cerebral symptoms preceding the inflammation in the eye; and when the patient is old enough to observe, the blindness will be said to have come on after the inflammation, and not to have existed before it. The whitish reflex from the fundus very closely resembles that caused by glioma, especially if the lens has lost a good deal of its transparency. When it is possible

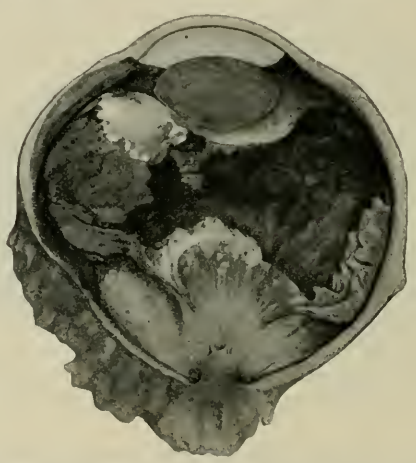


FIG. 162.—Section through eye and through the middle of a large glioma of the retina which has begun to invade the optic nerve.

to make a closer examination of it, the colour is found to be more of a faint straw, and not the pinkish-white or pure white characteristic of glioma. There is, besides, not the marked and irregular convex surface of the mass, or the appearance of retinal and other vessels on its surface, which is met with in glioma. The tension is almost always diminished, and there are also evident signs of inflammation—synechiæ, uveal pigment on the lens capsule, etc. An important point to observe, too, is the condition of the periphery of the iris. When there are purulent deposits in the vitreous, the contraction which takes place in them leads usually to retraction of the peripheral portion of the iris, and deepening of the anterior chamber in this position. In glioma the tension

is rarely low, and may be distinctly increased even before glaucomatous symptoms become evident. The shallowing of the anterior chamber takes place throughout, and is due to the pushing forwards of both lens and iris.

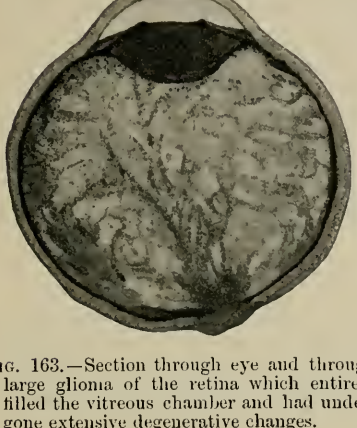


Fig. 163.—Section through eye and through large glioma of the retina which entirely filled the vitreous chamber and had undergone extensive degenerative changes.

Glioma is less frequent than sarcoma. It is much most common in infants, but has been met with up to the age of 12.

The children affected are otherwise healthy. So are their parents, as a rule; there does not appear to be any heredity. There is, however, a very marked tendency to several members of the same family becoming affected with the disease, though it is rare that this predisposition extends to all the members of a family. Occasionally both eyes are affected, and generally then both at the same time, or one shortly after the other. On this account alone it is evident that the disease in the second eye is independent of the first, and does not spring from a continuity of the growth along the chiasma. But there is absolute proof of this independence in the fact that complete recovery may take place after removal of both eyes for glioma.

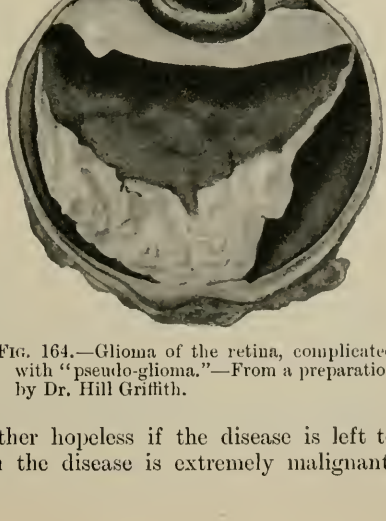


Fig. 164.—Glioma of the retina, complicated with "pseudo-glioma."—From a preparation by Dr. Hill Griffith.

The *prognosis* in glioma is always bad, and altogether hopeless if the disease is left to its own course. Although the disease is extremely malignant,

it is mainly so on account of the great tendency to extension to the brain. If an opportunity occurs of operating at an early stage, there is a fair chance of eradicating it. It is always advisable to remove as long a portion of the optic nerve as possible when there is much thickening of it. If the operation is done during the glaucomatous or later stage, the whole contents of the orbit should be removed. Even with this precaution the chance of recurrence is very great—quite as great as in the case of sarcoma, if not more so. The prognosis is therefore considerably more favourable than in sarcoma if the operation is performed early, while it is, if anything, worse in the third stage.

CHAPTER XV.

DISEASES OF THE ORBIT.

Inflammation of the Orbit.

Although it is not always possible to make the differential diagnosis, it is important to make a clinical distinction between *orbital periostitis* and *orbital cellulitis*. While the former sooner or later extends to the cellular tissue, an original cellulitis does not lead to inflammation of the periosteum or bone.

Cellulitis is the more common affection, being set up, as a rule, by some trauma, or by the extension of a panophthalmitis, originating often in some severe corneal inflammation. Of purely idiopathic inflammations, however, it should be remembered that periostitis is much more frequent than cellulitis. The *periostitis* may be an extension from some other part, or it may originate in the orbit. It may be merely hyperplastic, or it may be gummatous, and lead to the destruction of the tissue involved.

The surrounding cellular tissue and fat frequently participate in the inflammation which has originated in the periosteum, and a more or less localised abscess results, which gives rise to proptosis and great pain. When the case is originally one of periostitis, and the protrusion of the eyeball great, then it may be looked upon as certain that it has proceeded to suppuration. Sometimes fluctuation can be felt in the orbit, but this is not always the case. The pain is very great, and subject to extremely acute exacerbations, which are apt to come on at night. In many cases pressure over some part of the bone surrounding the orbit gives rise to pain, especially if the pressure is made with the finger passed as far to the inner surface of the orbital margin as possible and directed away from the eye. In this way a periostitis may often be distinguished from a cellulitis. If, however, the site of the inflammation is very far back, there may be little or no pain on pressure over the bone.

In both periostitis and cellulitis there is more or less chemosis, as well as swelling and redness of the lid. In cases of idiopathic cellulitis, in which alone, as a rule, there can be a doubt as to the diagnosis, the vision is more frequently seriously affected or altogether destroyed than in periostitis.

When an abscess does form, it should be opened aseptically. In the deeper-seated abscesses, too, it is important not to delay too long in making a free opening for the escape of the pus and for subsequent free drainage. Besides, by direct transmission through the diseased bone forming part of the orbital wall, cases

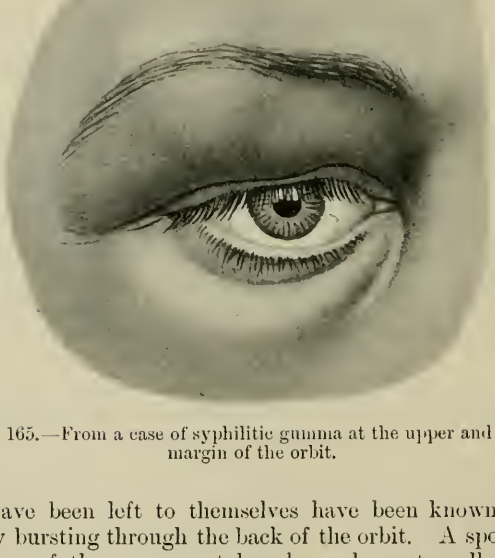


Fig. 165.—From a case of syphilitic gumma at the upper and outer margin of the orbit.

which have been left to themselves have been known to cause death by bursting through the back of the orbit. A spontaneous evacuation of the pus may take place also externally through the lid and conjunctiva, or into the cavity of the nose or the antrum.

The caries or necrosis so often associated with the periostitis causes the healing process to be usually a protracted one, so that a fistulous opening may remain for months. Where such a process takes place at the orbital margin, the eventual cicatrisation is apt to lead to ectropion. Children are especially liable to periostitis of the orbit, both in the superficial and deep parts.

Often it is apparently set up by a trauma, though probably there is generally a strumous or inherited specific taint which favours its occurrence.

Idiopathic orbital cellulitis is due either to thrombosis of the cavernous sinus or to an inflammation which is set up by some specific poison, which, somehow or other, finds its way to the tissues of the orbit.

The inflammation thus originating in the orbit may extend to the brain. When this takes place, it is probably always through the vessels, and not through the lymphatic channels. However it may originate, an idiopathic inflammation of the orbital tissues is much more liable to cause either complete destruction of, or grave interference with, vision than that which results from accident.

The danger to life is also greater in the idiopathic cases. Indeed, those which primarily depend on thrombosis of the venous sinus are always fatal, and usually the exophthalmos is at the same time double. It is not clear why in some cases which have a peripheral origin a spreading of the inflammation to the brain, and consequently generally a fatal termination, occurs, while in other apparently similar cases this complication is not met with.

The affection often begins with fever, and more or less marked indications of gastric irritation; not infrequently there is an evident erysipelas of the face and head which has spread to the orbit, or a lesion of some kind in the neighbourhood of the eye, which has given rise to phlebitis.

Probably in both cases the result is a more or less extensive thrombosis of the veins in the orbit, which may extend to the central vein of the retina and cause blindness, or, by extending backwards, lead to phlebitis and thrombosis of the cavernous sinus. Often, however, no such tangible cause can be discovered. In such Leber assumes, nevertheless, the existence of some similar infectious cause. He says "that the origin of the orbital inflammation is to be regarded in the same light as probably everyone now looks upon the occurrence of an apparently spontaneous attack of erysipelas, namely, that infectious matter finds its way into an unnoticed abrasion of the skin. The wound thus infected is probably generally in the lid, which, owing to its abundant venous supply, offers particularly favourable conditions for the establishment of an infected thrombus." An orbital cellulitis of this nature is usually confined to one eye.

In orbital cellulitis caused by erysipelas, death occurs from

extension to the brain in about 25 per cent., and is more likely to occur when both orbits are affected than where the exophthalmos is on the one side alone. It is considerably more likely than not to be followed by complete blindness.

The *treatment* of inflammatory exophthalmos must be directed, as far as possible, to preventing the retention of pus in the orbit. Before the protrusion of the eye is great, and so long as actual suppuration has not taken place, the treatment should be mainly expectant, or at all events no active local treatment is required. Constitutional remedies suited to the case may be tried, and a firm bandage applied over the eye. It should be remembered that some cases disperse without leading to abscess. This favourable result is not to be expected when the pain is excessive and the exophthalmos marked.

Tumours of the Orbit.

The orbit may be the seat of both simple and malignant new growths; and these, again, may primarily form in the orbital tissues, or invade them by extension from neighbouring parts. Some malignant tumours in this situation are metastatic.

Although, from a clinical point of view, the most satisfactory division of orbital tumours is into simple and malignant, it is more convenient to consider them according to the structures from which they spring. The tumours which may be recognised according to such a classification are—(1) Tumours of the bony wall of the orbit; (2) vascular tumours of the orbit; (3) tumours of the connective tissue; and (4) tumours of the optic nerve. Tumours of the lachrymal gland are, properly speaking, also orbital.

Orbital tumours are, comparatively speaking, of rare occurrence. Of 2058 tumours met with by Billroth, 217 occurred in the face and neck, and of these only eighteen were in the orbit. Tumours originating in any part of the orbit, though they may lead to the destruction of vision—occasionally, when they set up inflammation, to destruction of the eye itself—do not spread to the eyeball. When, therefore, a growth is seen to occupy both the globe and the orbit, as is by no means uncommon, it may be inferred that the starting-point has been the eye itself. As they extend within the orbit, new growths lead to more and more exophthalmos, and at the same time to more or less marked interference with the movements of the eye, giving rise consequently to diplopia, as long as the vision is sufficiently retained in the displaced eye. The direction of

greatest displacement affords an indication, too, of the position occupied by the tumour. Growths of the nerve itself or its sheaths, or growths which lie within the cone of muscular fibres which extends from the apex of the orbit to the eyeball, cause less interference at first with the movements of the eyeball, and at the same time displace it directly forwards. In the case of growths springing from other parts, there is often a preponderance of displacement in some particular direction. Great differences are met with in the amount of pain caused by a tumour of the orbit, the malignant growths being on the whole more painful than the benign tumours, but not so markedly so as to render the degree of pain a point of much practical diagnostic importance. The vision of the eye may remain perfectly good notwithstanding considerable proptosis, but many orbital growths sooner or later lead to its destruction. The vision is generally lost by neuritis or optic atrophy from pressure; rarely, if ever, owing to the nerve being actually involved in the tumour growth.

Tumours of the bony wall of the orbit.—Osteomata or exostoses of the orbit are exceedingly rare.

The tumours consist of excessively hard close bone, like ivory exostoses elsewhere. They are mostly found at the upper and inner angle of the orbit growing from the frontal bone, while next in point of frequency are those growing from the ethmoid. But they may apparently occur at any part of the orbit. They usually grow very slowly, so that years may elapse after they have first begun before they attain any size. The extension either takes place into the orbit alone, causing a gradual displacement of the eye,—to which the eye may accommodate itself to a great extent, but which eventually causes its destruction,—or it may take place at the same time into the cranial cavity or the maxillary antrum, according to the situation of the growth.

The *etiology* of exostosis seems to be altogether obscure. There is generally not much difficulty about the *diagnosis*—the slow growth, excessive hardness, immobility, and direct connection with the bone being sufficiently characteristic. If left alone they do not appear to destroy life, even if they at the same time grow into the cranial cavity. Their gradual enlargement may, however, lead to eventual destruction of the eye.

Treatment.—Frontal exostoses may be left alone as long as they do not interfere with vision by pressure on the eye. When this takes place they can be removed with almost complete safety by drilling a number of holes through their base, where they are usually thinnest, with a dentist's drill, and completing the separation by means of a small circular saw attached to the

same apparatus, and a hammer and chisel. The latter should be used with as little force as possible, as it may lead to fracture of the bone from which they grow, unless the neck of the tumour has been sufficiently weakened by the perforations. By this means the exostoses are not completely removed, and a repetition of the operation may be necessary after the lapse of some years. Complete extirpation has often been effected, but is risky in all cases where there is a possibility of some of the tumour extending into the cranial cavity. It has often been followed by a fatal result from injury to the brain. The results of extirpation of exostoses of the ethmoid have been much less unfavourable.

Vascular tumours of the orbit.—Nævi are occasionally met with extending from the skin of the face into the orbit.

The best *treatment* for such tumours, as well as for nævi in the orbit, is electrolysis.

Tumours of the connective tissue, etc., of the orbit.—These are simple or malignant, the latter being more common.

The simple tumours met with are cysts and lymphadenomata. The cysts are either dermoid or hydatid.

The *diagnosis* is difficult in all cases, but least in cases where there is fluctuation, and a history of the condition being probably congenital. With the exception, perhaps, of some true optic nerve tumours, the congenital conditions which cause exophthalmos are only dermoid cysts and angiomata. As they go on increasing in size, the *treatment* consists in removing them as thoroughly as possible.

A curious variety of orbital cysts has been met with by Talko and others in cases of anophthalmos and microphthalmos, which appears to be a cystic degeneration of more or less of the embryonic structures which should go to form the eye.

Hydatid cysts are comparatively rarely met with in the orbit; and in this country, where the echinococcus is altogether not very frequent, exophthalmos due to this cause is probably much rarer than that resulting from a dermoid cyst. The diagnosis cannot well be made with any certainty.

Malignant tumours.—The primary malignant tumours of the orbit are mainly, if not entirely, sarcomata. Carcinomata do occur, but, except in the cases of tumours of the lachrymal gland, they are probably always metastatic. Primary sarcoma of the orbit is usually non-pigmented, but melanotic sarcoma has been met with originally growing from the orbital fat. It is most frequently, however, an extension from an intra-ocular tumour. Various forms of sarcoma occur in the orbit, much

the most frequent being the round and spindle-shaped varieties. The rapidity of their growth depends partly upon the tumour itself, and partly on the age of the patient. Round-celled sarcomata, as elsewhere, are the most malignant, while the younger the patient the greater is the tendency to rapid growth. The tumour may extend to the brain, and also to the antrum, temporal fossa, etc. Sarcoma of the orbit is usually painful—more so, at all events, than most simple orbital tumours. It is usually fatal, although sometimes early removal may altogether eradicate the disease. Occasionally the growth stops spontaneously, and the tumour undergoes various degenerative changes. This is,

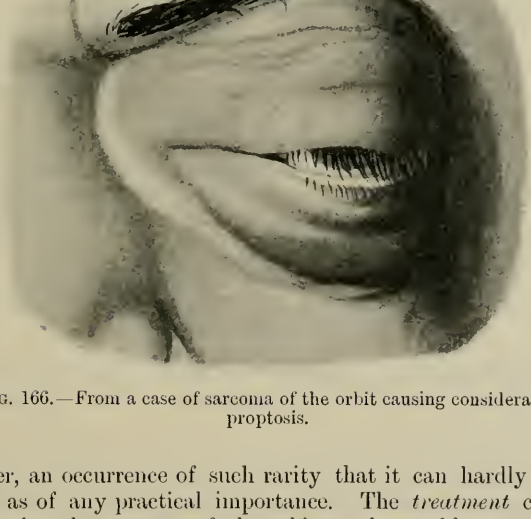


FIG. 166.—From a case of sarcoma of the orbit causing considerable proptosis.

however, an occurrence of such rarity that it can hardly be regarded as of any practical importance. The *treatment* consists in removing the contents of the orbit as thoroughly as possible. Healing after evisceration of the orbit may be materially hastened by covering the granulating surface after some time with a Thiersch's graft.

Tumours of the optic nerve are of rather rare occurrence. As the muscles are not involved in the tumour, the movements of the eye are generally relatively good, even when the proptosis is considerable. The eye, though as a rule soon rendered sightless, remains intact until the protrusion is so great that it cannot be

covered with the lids. Until the cornea becomes affected from exposure, there is complete absence of pain. A very considerable degree of antero-posterior flattening of the eye may take place as the tumour increases in size. The eye, when enucleated, may thus have an appearance which is different in this respect from that caused by other orbital tumours.

A suspicion that a tumour in the orbit was of this nature should be raised by the movements of the eye being good, by the early, though not absolutely sudden, loss of vision, and by the comparative absence of pain; but the *diagnosis* cannot always be made with any certainty. In some cases of sarcoma of the orbit sudden blindness may come on, probably owing to compression from hæmorrhage.

The progress of these cases of optic nerve tumour is very slow, generally lasting for many years. Most have been myxomata, or combinations of other forms of tumour with mucoid tissue. The tumours do not involve the outer sheath of the nerve. The result of operation has not generally been satisfactory. In one of the cases on which I operated, no recurrence took place. In another, in which I removed the tumour by Krœnlein's method, leaving the eye, there was no recurrence after three years. The tumours are always found to be encapsuled; but, unless removed at a comparatively early stage, may have spread too far backwards along the nerve to admit of complete removal.

Tumours which extend to the Orbit from adjacent Parts.

Encephalocele.—This is a very rare occurrence in the orbit, although the possibility of its existence should be borne in mind.

The *diagnosis* could hardly be a matter of difficulty, when, as has mostly been the case, the appearance presented is that of a fluctuating, somewhat transparent, and more or less distinctly pulsating tumour at the inner angle of the orbit, pressure on which causes its disappearance, and at the same time gives rise to symptoms of cerebral irritation. The history, too, of its being congenital is of diagnostic importance. In some cases, however, there have been complications which have rendered the diagnosis difficult; thus the encephalocele has been completely shut off from the cranial cavity so as to form a true cyst, or the skin covering it has been abnormally supplied with blood vessels, giving rise to the appearance of a nævus. In such cases the

appearance of hydrocephalus, as Berlin suggests, would weigh in favour of the growth being an encephalocele, and further evidence would be afforded by the condition being bilateral, or by the presence of an undoubted encephalocele in some other situation. The large and rapidly-growing tumours of this nature soon prove fatal, generally in the first few weeks, so that it is only in the case of the smaller ones, where it becomes possible for the patient to attain to full growth, that there is likely to be any doubt as to its nature. In any case it is probably safest to avoid interference.

Nasal polypi sometimes extend into the orbit and cause displacement of the eye. More or less complete blindness is thus produced by pressure.

Tumours of the ethmoid, sphenoid, and antrum may spread to the orbit. Primary sphenoidal tumours appear to be very rare.

Tumours of the lids and skin of the face—epithelioma principally—may spread eventually into the orbit and cause exophthalmos.

Aneurysm of the Orbit.

Aneurysm of the orbit is not an extremely rare affection. Sattler collected records of 106 cases from the literature of rather more than seventy years. Apart from the fact that many cases remain unpublished, in this country at all events,—and of such I have myself seen eight, and heard of several more,—the attention which has recently been drawn to the subject has led to the publication of a number of cases.

The aneurysmal protrusion of the eye is usually on the one side alone, but may be bilateral. The bilateral cases form, probably, about 7 per cent. of all cases.

The symptoms of aneurysm of the orbit are—exophthalmos with pulsation to be felt over the eye, and a more or less continuous murmur, which can be heard over the forehead and eye. On pressure over the protruded eye it can to a great extent be replaced, and on relief of the pressure it immediately returns to its former position. The vessels of the lids are greatly distended, and the lids themselves red. The retinal veins are found on ophthalmoscopic examination to be very greatly dilated, often exhibiting a marked pulsation, while at the same time the arteries are usually diminished in calibre. There may sometimes, too, be found an appearance exactly like neuritis.

The subjective symptoms complained of are pain and noises in the head and ears. The pain may be excessive, and is gener-

ally most distressing at an early stage of the affection. The noises appear to be much more troublesome in some cases than in others; they sometimes greatly interfere with sleep. They cease, or are much diminished in intensity, by compression of the common carotid artery, which at the same time causes the murmur and pulsation over the tumour to disappear. When the aneurysm, as is usually the case, is suddenly formed, the patient is conscious of a great noise, which is sometimes described as like the report of a pistol or the crack of a whip, in the head.

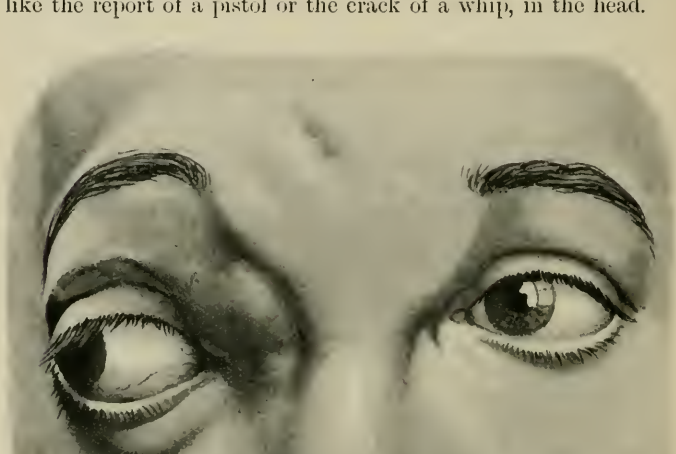


Fig. 167.—Aneurysm of the orbit.—From a case of Dr. Argyll Robertson's.

Aneurysm of the orbit may be either idiopathic or traumatic. The latter is caused mainly by severe injuries to the head, which have generally at the same time produced fracture at the base of the skull. A few cases have been the result of penetrating wounds in the orbit. Traumatic orbital aneurysm is more common in men, who are more exposed to accidents, than in women. Idiopathic orbital aneurysm, on the other hand, has been met with more often in women than in men. Sattler's statistics give over 70 per cent. in women, and from 30 to 50 as the most common age for its occurrence. All the cases I have seen have been in women.

There are a good many different possible causes of aneurysmal proptosis, and no doubt most of these have actually happened. The following have been demonstrated on post-mortem examination :—Spontaneous as well as traumatic rupture of the internal carotid artery in the cavernous sinus, aneurysm of the ophthalmic artery in the orbit, and of the same artery in the cranium. The first is undoubtedly by far the most frequent cause. The effect of the giving way of the arterial wall in this position is to cause an increased pressure within the sinus, and a consequent retardation of the current in the orbital veins, and therefore mainly in the ophthalmic vein. Pulsation, however, probably only begins when, after dilatation of the veins, the blood current is reversed in them, so that arterial blood courses through the dilated ophthalmic vein. On this account it is generally found that some considerable time elapses between the occurrence of the lesion which has caused the rupture, and the establishment of a pulsating tumour in the orbit, with exophthalmos.

The *prognosis* of orbital aneurysm is bad as far as the vision goes when the case is left to itself, but the condition seems rarely to cause death. A few cases have undergone a spontaneous cure, probably from thrombosis which has spread to the sinus, and has eventually even led to a closure of the aperture in the arterial walls.

The *treatment* of orbital aneurysm may be divided into medical and surgical treatment. The fact that several spontaneous cures have taken place might well encourage a trial of such measures as are likely to diminish the blood pressure and favour coagulation, before resorting to any more radical interference with the circulation of the parts affected; and indeed by rest, low diet, local or general blood-letting, the application of ice compresses over the orbit, and the internal administration of tincture of veratria, iodide of potassium, etc., good results appear actually to have been obtained. Various surgical methods calculated to lead to coagulation in the vessels of the orbit have been from time to time tried. Of these, the safest is undoubtedly electrolysis. This treatment is not likely, as a rule, to lead to sufficient coagulation in the case of the common cause of aneurysm of the orbit, namely, rupture of the carotid in the cavernous sinus, to effect a firm closure of the breach in the arterial wall against an undiminished blood pressure.

A larger range of usefulness might be expected by combining electrolysis with digital compression of the common carotid on the affected side. Compression alone, though it has led to a few cures, has, on the whole, been unsuccessful; still it should

always be given a trial before resorting to ligature, and especially would it be advisable to make the trial in conjunction with electrolysis. Ligature of the common carotid has proved successful in rather over 60 per cent. of the recorded cases in which it has been tried. The cure has usually been effected within six weeks after the operation, though in some instances it has been delayed for a good many months. When it fails, the treatment should consist first in digital compression, and afterwards ligature of the other carotid, which has in two cases at least been successful. In cases in which recurrence takes place after ligature of the carotid, it has usually done so very shortly after the operation; and indeed, as a rule, it is not many hours after the stoppage of this channel that the pulsation and murmur over the tumour make their appearance, even in the cases which are eventually cured by the ligature. Some cases have, however, only recurred after an interval of several months.

Injuries to the Orbit.

Bleeding into Tenon's capsule.—A disagreeable and somewhat alarming *contretemps* occurs occasionally during the performance of tenotomy of the recti muscles for strabismus. All at once the eye is found to begin to protrude, and in a few seconds becomes rigidly fixed, so that if the operation is not completed, it then becomes impossible to complete it, and indeed the lids can hardly be separated. This is due to bleeding into Tenon's capsule. I have observed it altogether about a dozen times, both in my own practice and that of others. Generally, it is owing to the opening made in the capsule being too small for the escape of blood, which, when an unusually free bleeding occurs, may take place into the capsule, from which it cannot be dislodged even if the opening be at once made, as it rapidly passes all round the eye and coagulates. No harm seems ever to result from this accident beyond a very black eye. When it occurs, the patient should be kept in bed for the day, and ice compresses applied over the eye for some hours, until the swelling becomes less tense.

Other cases of effusion of blood inside the orbit are caused by perforating wounds or injuries to the head, which have usually at the same time led to fracture of some of the bones of the orbit. Protrusion of the eye from hæmorrhage into the tissues behind it is a condition which may generally be inferred to be present when the proptosis has taken place suddenly after a severe blow on the head. It is a symptom of great gravity, as

even the few cases which have been recorded, where there has been no fracture of the orbit, have ended fatally, while it is almost a certain indication of such a fracture. Sometimes, indeed, there can be no doubt of this, as the blood escapes by the nose or mouth. That which is caused by a perforating wound is not so serious, and generally, if it has not caused an aneurysm, becomes absorbed in a few weeks. Besides the exophthalmos caused by the hæmorrhage, there is more or less ecchymosis produced after some time in the conjunctiva and lids, which renders the diagnosis of the cause of the protrusion easy.

Where there is a fracture of the orbit, it not infrequently happens that the line of fracture passes through the optic foramen, and thus, by laceration of the nerve or hæmorrhage into its sheath, gives rise to sudden blindness.

Foreign Bodies in the Orbit.

Foreign bodies of different sizes may become lodged in the orbit. Often this accident happens without the patient being

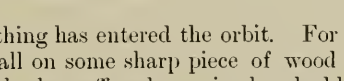


Fig. 168.—Piece of clay pipe stem removed from the orbit (natural size).

aware that anything has entered the orbit. For instance, it may result from a fall on some sharp piece of wood or branch of a tree, which has broken off and remained embedded in the orbit, but not observed owing to the patient being at the same time stunned. At other times it is caused by the breaking off of a knife or some other weapon with which the patient has been accidentally or intentionally wounded in this situation. Several foreign bodies even may be lodged in the orbit as the result of some explosion.

Fig. 168 is a drawing of a piece of a clay pipe stem which I removed from the orbit of a young man. It was deeply embedded, and remained there for ten days, without causing an abscess or in any way damaging the eye. I have seen two other cases of the same accident.

The possibility of a foreign body being present should always be borne in mind in connection with the treatment of cases of penetrating wounds of the orbit. An accident of this nature is not so very uncommon, and most frequently the foreign body is

situated to the inner side of the orbit. It causes exophthalmos, the eye at the same time being displaced in accordance with the position occupied by the foreign body.

The *diagnosis* may be difficult, but can generally be made by careful probing. The *treatment* then consists in removing the obstacle, which usually, unless there be others present as well, soon leads to healing. Sometimes the injury causes death. When this is the case, it is generally either owing to the direct wounding of the brain, or to hæmorrhage.

Graves' Disease.

The main symptoms of this disease are—(1) Rapidity of the heart's action; (2) enlargement of the thyroid; (3) protrusion of the eyes. The association of the two last symptoms have led to the name *exophthalmic goître*, which is frequently used as synonymous with Graves' disease.

All these symptoms are not invariably met with in Graves' disease; thus there may be palpitation and goître alone, or with hardly any appreciable protrusion of the eye, or the palpitation may exist along with proptosis alone, the thyroid being not appreciably enlarged.

The increased rapidity of the heart's action is the most constant and essential symptom, so that although exophthalmos from Graves' disease may exist without any appreciable cardiac acceleration, the diagnosis of the true nature of the protrusion of the eyeballs under such circumstances is difficult or altogether uncertain. In most cases the heart beats amount to from 100 to 160 in the minute, but they are sometimes more frequent. The pulsation is felt very distinctly over the carotids, which are most frequently what have been called "hammering carotids." They, as well as other arteries of the head, are dilated. The veins in the neck are also dilated, and on auscultation over them a hæmic murmur can generally distinctly be heard.

The goître has usually a soft elastic feeling, and communicates to the hand either a very distinct pulsation or a thrill which is synchronous with the systole of the heart. The enlargement varies very much in different cases; it is rarely extreme. Not infrequently the one lobe of the thyroid, and almost invariably the right, is more enlarged than the other. Cases are on record where death has occurred from dyspnœa, caused by the pressure of the enlarged thyroid on the trachea. In other cases, again, it has been found necessary to remove the isthmus to prevent this occurrence.

The exophthalmos is almost always bilateral, though not infrequently one eye is protruded more than the other. Occasionally it is altogether confined to one side. The protrusion of the eye takes place directly forwards; and in most cases, and always where the disease has not existed for any great length of time, the eyes may be pressed back into the orbit without much difficulty, but regain their former position on the relief of the pressure. A hæmic murmur may be heard on auscultation over the eye. The degree of protrusion varies very much. In many cases it goes on increasing slowly or rapidly for some time, and then again becomes less; in others it remains pretty much the same, though subject to slight differences, according to the patient's state of health. It may be so excessive as to render it impossible for the lids to cover the eyes, or even cause the eyes to become dislocated out of the orbit. Such a degree of exophthalmos is, however, very exceptional.

The exophthalmos of Graves' disease is in most cases accompanied by a frightened, staring appearance, which is very characteristic, and due to the greater than normal retraction of the upper lid. This involuntary widening of the lid aperture generally goes by the name of "Stellwag's sign." Stellwag pointed out at the same time, that in cases which exhibit this symptom there is a more or less complete absence of involuntary blinking. This retraction of the upper lid is not met with in other forms of exophthalmos, and is therefore a point of diagnostic importance in the cases where exophthalmos is confined to one side, or not accompanied in a marked degree by the other symptoms characteristic of Graves' disease. It is generally supposed to be due to contraction of the unstriped muscular fibres of Müller. Ferri has, however, adduced experimental evidence which seems to indicate that shortening of the levator palpebræ superiori, due to the mechanical effect of its vascular engorgement, may be the cause. An appearance very similar to Stellwag's sign is produced by cocaine dropped into the eye.

A more important, though less frequent, symptom is that which is called "Graefe's sign." This consists in the loss of association of the movements of the upper lid with the eye. Thus, when the eye is directed downwards, the upper lid either does not follow it at all, or more frequently moves along with it for a certain distance and then remains stationary. Graefe's sign is also highly characteristic of Graves' disease, and is not found at all, or only extremely rarely, under other circumstances. It may be seen, like the retraction of the margin of the upper lid, before proptosis takes place, or may occasionally first make

its appearance later. It may also not be present during the whole course of the disease, but disappear after having existed for some time. It is absent in some cases in which Stellwag's sign is well marked.

Notwithstanding the presence of these characteristic symptoms, there is no defect in the closing of the lids, the voluntary movements of which are retained just as in health, so that it is only when the proptosis has become very excessive that the eyes cannot be properly covered. In such cases, and even it would appear in some cases in which the lids can still be made to afford a sufficient covering, a kind of neuro-paralytic keratitis takes place, which is extremely likely to cause destruction of the cornea. In this way, but apparently only in this way, is the sight endangered by the disease; but such cases are also the ones in which the prognosis is serious for the life of the patient as well.

Besides the main symptoms of Graves' disease which have now been described, there are other more or less constant ones. One, which in women at all events is often most marked, is an excessive degree of nervousness. The patient is easily startled and frightened, and very readily blushes or is subject to attacks of perspiration. In some of the worst cases rapid emaciation also takes place. More or less anæmia is generally present at the same time, and this may in women be accompanied by menstrual disturbance.

Graves' disease is very much more frequent in women than in men. More than half of the cases in women occur between the age of puberty and 30, a very few before puberty or after the climacteric period. In men, although cases are also met with in young individuals, the average age for the disease to make its appearance is between 30 and 50. It often seems to come on after mental anxiety, worry, or shock.

The course of the disease is usually very chronic. It may last for years in much the same condition, or occasionally undergo an improvement in one or more of its symptoms. After continuing in this way for some time, the symptoms gradually in great measure subside, though frequently some enlargement of the thyroid, and often a not inconsiderable degree of exophthalmos, permanently remain. Again, a number of cases never completely recover.

The frequency of the disease in women, and its occurrence mainly during the child-bearing period of life, has led many to believe that Graves' disease is intimately connected with affections of the reproductive organs. The occasional occurrence of

the disease in women at other times of life, as well as in men, and the absence frequently of any menstrual disturbance, would, on the other hand, point to such a connection not being very intimate. In these cases, too, in which derangements of menstruation are observed, they may well be ascribed to the condition of anæmia, which is so frequently present in this disease. Unmarried women seem to be more subject to the disease than married, and pregnancy is supposed by many to exert a favourable influence on it.

The *pathology* of Graves' disease is still very obscure. Post-mortem examination in cases which have ended fatally has done very little to clear up the difficulty. Some change in the orbital fat—hypertrophy, enlargement of the vessels, etc.—has generally been found. There can be no doubt that both the enlargement of the thyroid and the exophthalmos are originally due to engorgement of vessels, and it is not unlikely, again, that after long continuance of the process some hypertrophy of the tissues may take place. Still, the protrusion of the eye is mainly a vascular one.

Treatment.—There is certainly nothing which can be said to approach the nature of a specific remedy for Graves' disease. Many things have been tried: iron, iodine, belladonna, veratria, bromide of potassium, and other drugs; but though all have had their special advocates, their direct beneficial effects on the disease cannot be regarded as more than doubtful. The most important indications for treatment are—freedom from excitement and worry, and change of air. If drugs are used at all, iron and bromides are perhaps the best; iodine, too, may be used as an external application to the goître. A few cases have been apparently improved by removal of the goître; but except where it endangers life by pressure on the trachea, such treatment would not be justifiable. In cases where the protrusion of the eye is excessive, the lids may be kept closed by bringing them together by means of horse-hair sutures.

Enophthalmos, or the sinking back of the eyeballs into the orbit, exists as a consequence of the disappearance of the orbital fat in very old people. It is also met with in some cases where there has been fracture of the bones of the orbit. It has occasionally been observed, too, apparently as a rare vaso-motor affection, but little is known of the pathology of this form.

Shrinking of the orbit occurs sometimes when the eyeball has been removed in early childhood. The diminution takes place mainly, if not entirely, by approximation of the roof and floor of the orbit, while the sides retain their normal dimensions.

CHAPTER XVI.

AMBLYOPIA AND OTHER ANOMALIES OF VISION.

There are various alterations of vision which are not accompanied by any very definite objective signs. There may be complete blindness (*amaurosis*), or more or less defective vision (*amblyopia*), which does not arise from any lesion of any part of the eye itself.

The diagnosis of the cause of an amblyopia or amaurosis is often difficult enough. A careful study must be made of the subjective symptoms so far as they can be elicited. To some extent, too, one may be guided by the other coexisting conditions.

In some cases the colour vision may be defective, in others a particular portion of the field of vision may be lost or be functionally inactive. In others, again, the light sense may be abnormal. Under this category come cases of night blindness, in which vision may be normal in daylight, but defective so soon as the illumination of objects looked at is reduced beyond a certain degree.

Congenital amblyopia.—Defective vision, when congenital or originating early in life, often escapes observation until the difficulties experienced at school attract attention. The higher degrees of amblyopia are mostly associated with nystagmus. It is by no means an uncommon thing to find very considerable amblyopia and nystagmus without any marked objective cause, either in the dioptric or percipient parts of the eye. In such cases there is usually a history of early severe inflammation of the cornea, followed by dense opacities, which have slowly cleared away, leaving little or no trace; or of some cerebral affection, which has interfered, more or less completely, with the visual centres, and which has been followed by only partial recovery.

Congenital amblyopia, too, unaccompanied by nystagmus, is very frequently met with without there being any objective sign or any history to account for it. Frequently the degree of amblyopia where there is some defect is much greater than can

be accounted for by the defect alone. When amblyopia is present only in one eye, it is still more likely to pass unobserved, unless, as is frequently the case, it gives rise to strabismus, owing to the existence of other causes which predispose to that condition. Often a unilateral congenital amblyopia is only accidentally discovered late in life, when anything, some trifling accident to the eye, it may be, has drawn the individual's attention to it.

Simulated amblyopia.—Amblyopia is sometimes simulated. In this country it is rare to meet with this, and the deception is not so well carried out as a rule that there is much difficulty in detecting it. In other countries, where there is a compulsory military service, simulated partial or complete blindness is very common.

There may be a simulation of either bilateral or unilateral defect of sight. The latter is by far the more common, and fortunately, too, it is the more easily detected. It is mostly an amblyopia, and not a complete blindness, of the one eye which is feigned. The diagnosis may then not be at all easy. When bilateral amblyopia is simulated, a little ordinary care on the part of the individual is all that is required to make it almost impossible for one to detect it with certainty. Yet it is strange how often some inconsistency between the admitted sharpness of vision found on examination for distance and for near, or in connection with the glasses which are admitted to effect some improvement in vision, affords a clue to the character of the amblyopia. Often one finds, for instance, very considerable improvement of vision by the use of a convex and concave glass, which exactly neutralise each other. It requires, on the other hand, a very great amount of care, and considerable knowledge of the subject, to simulate well uniocular amblyopia. The certainty of the diagnosis depends pretty much, too, on the degree of the pretended blindness.

A great number of tests have been devised for the detection of this kind of deception, all of which it is probably possible to elude. An easily applied test is that which can be made with Snellen's coloured letters. These are transparent red and green letters of different sizes. The patient is first made to read them out without anything before his eyes. A pair of reversible spectacles, one eye of which is of green glass, and the other of red, is then put rapidly upon his nose, care being taken that the eyes are all the time kept open. As the green glass entirely excludes all the rays from the red letters, and the red all the rays from the green, some of the letters are visible only to the

one eye, and others only to the other. Any mistake made in the reading of the letters is in this way easily detected. The slightest blinking of one eye is sufficient to show one with which eye each particular letter is seen, so that with care it is possible for a clever deceiver to avoid falling into this trap, although the manner in which the individual behaves may be generally sufficient to arouse or confirm one's suspicions.

Another simple test, in cases where complete or almost complete blindness of one eye is simulated, consists in holding a prism, with its base directed upwards or downwards, in front of the good eye. If this produces diplopia, there is evidently vision in both eyes; but the object of this test, again, is of course easily defeated by anyone denying that he sees double. An important modification of the test is made by Alfred Graefe. The individual tested is made to shut the blind eye, and the prism is held in front of the good one, in such a position that some of the rays pass into the pupil through the prism and some directly. This causes uniocular diplopia. The patient, thus thrown off his guard, often admits that he still sees double when the blind eye is uncovered, and the position of the prism altered to the slight extent required to intercept all the rays passing into the pupil of the one eye, under which circumstances the diplopia is of course binocular, and its continuance is a proof of vision in the eye said to be blind.

A good plan in cases of simulated uniocular amblyopia, and one which at the same time affords some test of the degree of visual acuteness in the eye said to be defective, is to cause the patient to read through a strong convex lens ($+5{\cdot}0$ or $+6{\cdot}0$, if he be emmetropic), and then to slowly withdraw the print beyond the point at which it can be distinctly read through the lens. If under these circumstances the patient still continues to read, he must be doing so with the eye which he asserts to be amblyopic.

Von Graefe's test of placing a prism, with its base directed inwards or outwards, in front of the seeing eye, and observing whether a convergence movement is thereby induced, is perhaps the best test for simulated amaurosis of one eye; because, where binocular vision exists, such a movement always takes place involuntarily, owing to the unconscious desire for the fusion of the two images.

Amblyopia and amaurosis due to changes at the visual centres, etc.—A good number of cases of amblyopia and amaurosis occur more or less suddenly, and unaccompanied, for the time at least, by any ophthalmoscopic changes. In such cases

the diagnosis has to be made from a consideration of the history. When the blindness comes on in the course of a severe illness, or during the period of convalescence,—for instance, in scarlet fever, puerperal albuminuria, etc.,—the cause is more often uræmic, and the prognosis favourable, more especially if the pupils continue to respond to light.

Amblyopia or amaurosis occurring after severe hæmorrhage is very unlikely to be recovered from, and is generally followed some time after by optic atrophy.

The prognosis is even worse in cases of unilateral amaurosis after a severe fall on the head. These cases are of pretty frequent occurrence, and are probably almost invariably due to laceration of the optic nerve, or hæmorrhage into the sheath of the nerve, owing to fracture of the roof of the orbit, the line of which fracture usually passes through the optic foramen. The atrophy to which this lesion gives rise is not visible ophthalmoscopically until after some time.

The blindness which one meets with in young children, after severe cerebral symptoms, is unaccompanied by ophthalmoscopic changes, and is due to interference with the functions of the visual centres. It is often partially recovered from, but may be permanent.

The rare cases of blindness from lightning have not as yet received a proper explanation. On the whole the prognosis seems favourable.

In cases of lead poisoning very considerable blindness is sometimes produced. I have seen the blindness so great that there has been doubtful perception of light, and yet recovery take place. Some of the symptoms in these cases, more especially with respect to colour vision, are often very similar to what is met with in hysterical amblyopia. As in that form of amblyopia, too, there seem to be considerable differences in the nature of the visual defect, and also a good deal of inconstancy about the symptoms of any particular case. Amaurosis from lead poisoning, when unaccompanied by ophthalmoscopic changes, appears most frequently to be transient. It is one of the rarest symptoms of lead poisoning; and although different explanations have been offered, the true nature of the blindness is unknown.

Central toxic amblyopia.—The symptoms of this rather common affection are—gradual failure of sight, to much the same extent in both eyes; absence of any restriction of the field of vision, or indeed of any interference with the functions of the peripheral portions of the retina; and the existence of an oval scotoma, most marked for colours, extending from the point

of fixation, which it involves, to the blind spot. Most of such cases are met with in men after the age of 40. This form of amblyopia is very rare in women, though not quite so rare as was at one time supposed.

Those who suffer from it are almost invariably smokers; and generally they have smoked for many years before becoming affected. It is very doubtful if alcohol has anything to do with it. Certainly those affected not only smoke, but often also drink to excess; yet the same symptoms are never observed to follow the excessive use of alcohol alone, though they are very frequently met with in smokers who abstain completely from alcohol in any form. As a rule, when the affection begins, no change has been recently made in the amount smoked. On this account patients rarely suspect the cause of their amblyopia. Indeed, they not infrequently begin to smoke more after their sight has begun to fail, on account of the worry that this causes. Very often smoking is indulged in on an empty stomach, the first thing in the morning or very late at night, or, in the case of bad sleepers, during the night. It is owing to this circumstance, probably, more than to the difference in the kind of tobacco smoked, that tobacco amblyopia is more common in the working than in the educated classes. Many men have to rise early and work several hours before partaking of a substantial meal, but nevertheless smoke during this time.

The fact of the toxic effect of the tobacco getting at some particular time the upper hand, although individuals have smoked as much and often more at other times, and continuously for years, points to there being some recent diminution in the power of resistance. What this has been it is not always easy to find out. Sometimes there has been some slight indisposition or dyspepsia, sometimes loss of blood, at other times merely sleeplessness, anxiety, or trouble. A frequent cause, no doubt, is the undermining of the system produced by alcoholism, so that alcohol may thus be indirectly a factor in the etiology.

When any such predisposing cause exists, then smoking at a time when there is no counter stimulus of the food renders the poisoning action much more likely to take effect. According as such causes, too, are more or less pronounced, and dependent no doubt as well upon the individual tolerance of tobacco, we find in different cases of this form of amblyopia that the patients have been in the habit of smoking very different amounts of tobacco. As a general rule not less than 3 to 4 oz. of strong tobacco are smoked in the week, often much more—in exceptional cases less. In women a smaller quantity suffices to

bring on the symptoms. The same symptoms are produced by chewing tobacco.

It would be strange indeed if tobacco were the only poison which gave rise to central amblyopia. Cases do occur in which it is doubtful whether tobacco is the cause, as, for instance, when the amount consumed is very small, or where the blindness appears to have come on some time after smoking has altogether been given up; but, with the sole exception of bisulphide of carbon, which produces much the same symptoms, the evidence in favour of other poisons is as yet very far from conclusive.

Some cases of retrobulbar neuritis very closely resemble toxic central amblyopia, more especially when the defect produced by that inflammation is pretty similar in both eyes.

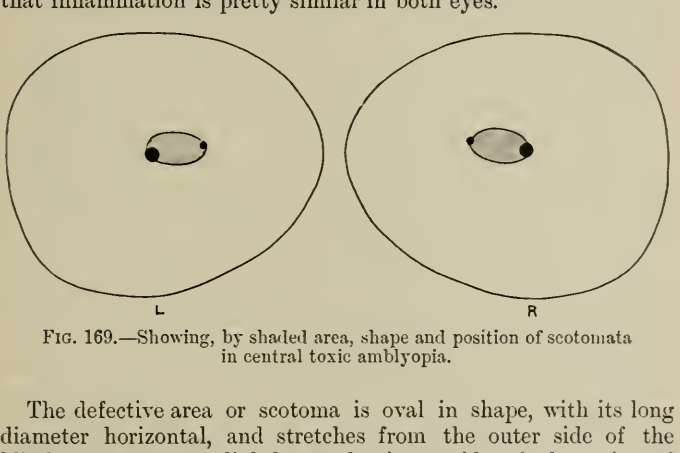


FIG. 169.—Showing, by shaded area, shape and position of scotomata in central toxic amblyopia.

The defective area or scotoma is oval in shape, with its long diameter horizontal, and stretches from the outer side of the blind spot to very slightly to the inner side of the point of fixation. It corresponds to the external projection of that portion of the retina which lies between the optic nerve and the outer margin of the macula, a portion which is supplied by a special bundle of optic nerve fibres—the so-called papillo-macular bundle. The form sense as well as the colour sense is defective over this area, but the patient is not conscious of a limited defect—that is, it does not appear in the form of an oval dark spot in the field of fixation, or, in other words, there exists what is called a *negative scotoma*.

Practically all that is required to diagnose a central scotoma is to cause the patient to fix some object, preferably on a dark background, a foot or two from his face, and then to hold a

small piece of coloured paper, first 2 or 3 in. to the outer side, and then a similar distance to the inner side of the point of fixation, when it will be found, if the scotoma is marked, that the colour is not recognised in the first situation, but is immediately recognised in the latter. As the defect is most marked for red and green, only these colours need to be used, unless there should happen to be at the same time congenital red-green confusion, when blue and yellow must be used instead. The limits of the scotoma can be mapped out with the colours, but for this purpose smaller squares should be used, and the shade not taken too bright.

By using very small white objects at a greater distance, the corresponding form-sense defect in the scotomatous area may usually readily be detected; that is to say, an absolute scotoma for white is also to be found. When the scotoma is not very pronounced, and the visual acuity consequently not greatly reduced, there is more difficulty in demonstrating its existence; it will then be found that although the ordinary colour of the test square is recognised to the outer side of the point of fixation, it appears more vivid and distinct when removed to the inner side. By using light shades of red and green in such cases, or simply by testing at a greater distance, the defective colour sense can be demonstrated with certainty.

As it is only over a particular area that the colour sense is impaired, the patients are often not aware of the colour defect they have acquired: a large surface of red or green appears to them quite as distinct as formerly.

Individuals with tobacco amblyopia often complain of seeing worse in a strong light. This is owing, apparently, to some co-existing hyperæsthesia of the retina, which causes any glare to be uncomfortable. They see white letters on a black background better than the ordinary black letters on a white ground.

The *prognosis* in tobacco amblyopia is on the whole very good. A large proportion of cases completely regain vision if the tobacco is stopped. Improvement, though less rapid, generally takes place when the amount consumed is reduced, or when the quality of the tobacco used is milder, or if cigars be substituted for pipe smoking, which is very much more injurious in this respect. It is also more likely to take place if smoking be indulged in only after meals. Sometimes, though very rarely, recovery may take place without any change of habit. When this happens, it is probably to be explained on the assumption that some condition of the system, which has permitted the

tobacco to get the upper hand and produce its poisonous effects, has been so far recovered from as to enable the individual to throw off the poison, notwithstanding the cumulative action which has taken place. It is not probable that the symptoms have been due to anything else.

A very varying time elapses between the stopping of the tobacco and complete recovery, depending partly on the degree of blindness and partly on individual peculiarities. Often there is a period of a month or six weeks, or even longer, before improvement begins at all.

In many cases where the vision is apparently reduced to much the same extent, there may yet be great differences in the density of the scotoma, and consequently in the extent of the toxic action which has taken place. On the whole, the younger and more healthy the individual, and the smaller the degree of blindness produced, the more rapid is the recovery likely to be.

The *treatment* consists in stopping the use of tobacco in any form altogether. Although merely diminishing the amount consumed may be sufficient, it is found, as a rule, easier, and it is certainly safer, to give it up altogether. In addition, either inhalation of a few drops of nitrate of amyl or the internal use of trinitrin in small quantities ($\frac{1}{200}$ gr.) sometimes appears to hasten recovery. Attention must also be paid to the general health, and an attempt should be made to improve any conditions by which the system is likely to be lowered.

The lesion which produces this peculiar form of amblyopia is not known. The regularity in the shape of the scotoma, as well as the complete recovery which so often takes place, render it extremely unlikely that it is a form of retrobulbar neuritis. In undoubted cases of that nature, although the central vision is mostly affected, there is rarely either a similar amount of blindness in both eyes, or any constancy in the shape of the scotoma, while at the same time there is not infrequently some slight peripheral restriction of the field, and rarely as complete, and certainly by no means as frequent, recovery. It is more probable either that the poisonous effect is exerted on some part of the brain which includes the central terminations of the papillo-macular fibres, or that some limited vasomotor change affects these fibres in some part of their course. Tobacco has been shown to have a direct toxic effect on nerve cells.

Apart from the cases of true retrobulbar neuritis referred to at page 267, there are others which exhibit the symptoms of

a central scotoma, but which, nevertheless, are not, correctly speaking, either cases of central or of toxic amblyopia. It is the existence of such cases, no doubt, which has led to the mistake of considering toxic amblyopia to be due to inflammatory changes in the optic nerve. The true cases of toxic amblyopia have not so far been examined anatomically.

Jensen classifies these atypical cases under the following heads: — Stationary scotomatous optic atrophy; progressive scotomatous optic atrophy; bilateral optic neuritis, with central scotoma; unilateral amblyopia, neuritis or atrophy, with central scotoma; and glaucoma simplex.

The most important of these groups is the *stationary scotomatous optic atrophy*. Cases of this nature were found to constitute about 25 per cent. of the atypical varieties of central amblyopia, or 7 per cent. or 8 per cent. of all the affections characterised at some time or other in their course by a central scotoma. Of this group Jensen gives the following description:—

"It occurs exclusively in young men under the age of 34, usually between the twentieth and twenty-fifth year; occasionally showing a hereditary tendency, sometimes apparently caused by want of sleep and other weakening factors; often without any demonstrable cause. The affection begins with considerable amblyopia, which occurs either suddenly or reaches a maximum in the course of a short time, without being accompanied by disturbances of general health; it develops usually simultaneously in both eyes.

"On examination of the field of vision a central scotoma is found of about the same size and form as in amblyopia centralis, but much more complete—white objects, presenting a visual angle of 1 to 2 degrees, disappearing either entirely or becoming very indistinct within its area. Corresponding to this, fixation is uncertain or eccentric. During its course the density of the scotoma, and consequently the central amblyopia, remains as a rule unchanged.

"The periphery of the field of vision may present slight anomalies in the colour sense; rarely complete or permanent red-green blindness. Further, transitory defects of peripheral vision for white objects may arise. As a rule, the periphery remains normal during the whole course.

"Ophthalmoscopically there is found to be complete atrophy of the papillæ, and this sometimes very early; as a rule, it is decided before the lapse of a year. Occasionally there may be a suspicion of a neuritic origin; on the other hand, a decided

intra-ocular neuritis is never found to precede the atrophy. The prognosis of this affection is bad *quoad restitutionem*, but absolutely good *quoad cœcitatem*."

Progressive scotomatous atrophy, which occurs with about the same frequency as the stationary form, is met with only in men of middle age, rarely if ever before 35. It is to be regarded more as a particular form of development of spinal atrophy than an independent disease, like either central toxic amblyopia or stationary scotomatous atrophy. There is frequently a syphilitic history, and an association with more or less well-marked premonitory symptoms of tabes dorsalis. The blindness usually comes on in the one eye before the other. The main points in connection with this affection are thus summed up by Jensen :—

The affection begins as a central amblyopia, with a central colour scotoma and intact periphery.

The scotoma has exactly the same form and degree of saturation as that in amblyopia centralis, and, just as is the case in that affection, the defect for white objects can only be discovered for minimal visual angles. During the course of the disease the scotoma retains its size and its relative character.

In the periphery, on the other hand, anomalies come on characteristic of progressive atrophy, the boundaries for colours become narrowed centripetally; and finally, though often very late, those for white also. At this stage the original scotoma is frequently unrecognisable; the disease runs a course similar to an ordinary progressive atrophy, and the prognosis is as bad as other cases of that description.

Complete atrophy of the papillæ comes on with certainty, and as a rule earlier than in the preceding form; it may generally be diagnosed at an early stage.

Hysterical amblyopia and amaurosis.—Various eye affections occur in connection with hysteria. These may take the form of pareses and other innervational disturbances of the ocular muscles, of asthenopia, of alterations of sensibility and of secretion, and of defects of vision, for which no anatomical cause is discoverable. There may be complete blindness, amaurosis, of one or both eyes. As a rule the blindness is not associated with loss of pupillary reflex. Sometimes, however, the pupils are found not to contract to light.

Diagnosis.—Hysterical amaurosis of one eye alone is by far the most commonly met with variety of this curious affection. Such cases are often difficult to distinguish from simulated uniocular blindness. This is particularly the case when the pupillary

reaction to light is normal. The absence of any conscious attempt to deceive the examiner makes it always easy to demonstrate the existence of sight in the "blind" eye, and even to determine its acuteness. It is only when the patient's attention is called to the images on the retina of the defective eye alone that these are found to awaken no conscious visual impressions. When used in participation with the other eye, the impressions which it receives can be shown to be in no way abnormal.

As all lesions situated centrally to the chiasma must necessarily affect both eyes, a lesion which produces a unilateral amaurosis without ophthalmoscopic changes must be located in the optic nerve itself. The differential diagnosis between such a lesion when it causes complete blindness, and unilateral hysterical amaurosis, with loss of pupillary reflex, may present some difficulty. For all other cases except retrobulbar neuritis, the history of the onset of the blindness, the concomitant conditions, and the patient's general state would probably always afford sufficient data for a differential diagnosis. Practically, therefore, the difficulty only arises in distinguishing between retrobulbar neuritis which has caused complete blindness,—a comparatively rare occurrence,—and unilateral hysterical amaurosis, with reflex pupillary immobility, a still rarer condition. The differential diagnosis can always be made later, or when recovery has taken place or is progressing. Both may be of sudden onset, but the progress of recovery in the former, when it does begin, is slower, and the visual functions as they are restored exhibit the characteristic defects of the light sense, and of the relative degrees of disturbance of the central and peripheral vision. Hysterical amaurosis, though it may last much longer, disappears more suddenly and more completely. It is often cured, too, by methods which are purely suggestive. A long-standing blindness due to retrobulbar neuritis will always be associated with some visible change in the optic disc. Too much importance must not be attached in early cases to pain, either spontaneous or produced by pressure of the eye back into the orbit. This, though usually present in retrobulbar neuritis, may be absent, while it may exist as a pure result of suggestion in hysterical amaurosis.

Double hysterical amaurosis is less frequent than the unilateral form, and is more often associated with loss or diminution of the pupillary reaction to light. The onset may be sudden, but it is not always so. A gradually increasing blindness, characterised by increasing restriction of the field of vision, may precede the total loss of sight. Recovery, though usually sudden, is also in some cases gradual. The duration is variable—from a few

weeks to many months. Double hysterical amaurosis is so characteristic that there can rarely be any difficulty as to diagnosis. The patient, though professedly unable to distinguish light from darkness, does not behave altogether like a blind person. There is, for instance, no stumbling up against objects, and there are many indications that visual impressions are produced, though the patient is not clearly conscious of receiving them.

The *treatment* usually relied upon for the cure of hysterical blindness, whether unilateral or bilateral, is the use of subcutaneous strychnine injections and electricity. There is no doubt that such treatment acts wholly by suggestion. I have been in the habit for years of using pure water alone, injected under the skin of the supraciliary region. This has often a powerful suggestive effect. In many cases one injection effects a complete cure, or causes very considerable improvement, which is still further increased by subsequent injections.

In some cases the hysterical blindness is not complete. One or both eyes may be merely *amblyopic*. Most frequently the defect in such cases is bilateral. The diagnosis may then be attended with some difficulty. There is always found to be more or less concentric restriction of the field of vision; and this, if associated with pallor of the optic discs, which is frequently met with where there is a coexisting anæmia, may suggest optic atrophy. In many respects, however, the symptoms, when carefully examined into, differ from those of atrophy. There is, for instance, usually some, often marked, improvement in the vision when the surrounding illumination is diminished, *i.e.*, in semi-darkness. In atrophy there is only a relative, never an absolute, superiority of the sight under similar conditions. The vision may even be materially worse in semi-darkness. The peripheral colour vision too, in the hysterical cases, is not lost, though it may show irregularities of a curiously atypical nature. The restriction of the field of vision for white is, besides, of the exhaustion type; that is, it is not constant in amount, and shows much greater differences than in non-hysterical defects of the field according as the test object is moved from centre to periphery, or *vice versâ*. Sometimes hysterical amblyopia is associated with local anæsthesia, mainly of the conjunctiva.

The condition of hysterical amblyopia is more essentially a neurasthenic one, as a rule, than is the case with hysterical amaurosis. Although it may yield to the same *treatment* as that recommended above, it is generally more difficult to remove, and may last for many years. Many cases are benefited by massage,

isolation, and stuffing, on the lines of the Weir-Mitchell treatment.

As regards the pathology of hysterical amaurosis, the mere occurrence of unilateral blindness, apart altogether from the fact that the sight is often suddenly and completely recovered, can, I believe, only be explained on the assumption that an interruption exists between the centres, to which visual impressions are conveyed, and the psychical mechanism—whatever that may be—which leads to the consciousness of these impressions.

Suppression of visual excitations is indeed common even under normal conditions. There is, for instance, a constant so-called struggle taking place between the fields of vision of either eye, which consists of a tiring of the attention alternately to images on parts of the one retina, while the images on corresponding parts of the other retina awaken fully conscious impressions. These, again, fade out in their turn, and give place to renewed consciousness of the retinal excitations of the same region in the first eye. Again, there is the well-known and often complete suppression of images in a squinting eye, which takes place as long as the fixing eye is uncovered, but disappears when the squinting eye is called upon to act alone. There is also the habitual suppression, as a rule, of physiological double images, those of objects not directly fixed or specially engaging one's attention.

The hysterical interruptions between the psyche and bodily excitations is therefore similar in many ways to what is constantly taking place in health, though its greater persistency and greater completeness, amongst other points by which it is characterised, may be difficult to explain.

Subjective sensations of light and colour may proceed from some irritation of the retina, or may be due to irritations of the visual centres in the brain. It is by no means always easy to detect in any particular case what is their origin. Generally speaking, photopsia due to retinal irritation is most evident after any prolonged exposure of the eye to strong light, or after anything causing fatigue either of the retina or of the body generally, and tends to become less marked or to disappear altogether when the eyes are rested, and therefore especially at night. Photopsia caused by irritation of the visual centres, on the other hand, is often most distressing at night, and at times when the eyes are not subjected to stimulation from the ordinary objective sources. In some cases of hyperæsthesia of the retina, complaints of coloured vision are made. This kind of chromatopsia is evidently the result of the response to stimuli, which

would otherwise, on account of their feebleness, be disregarded. Owing, however, to the irritable condition in the retina, or of the more central portions of the visual apparatus, these feeble stimuli evoke sensations, just as hyperæsthetic individuals may be affected with pains for which little or no objective cause can be detected.

A curious form of subjective colour sensation has received a good deal of attention. It is mostly met with in aphakia after cataract extraction, and consists in a more or less constant sensation of everything looked at being coloured a vivid blood-red. There is no veiling of the objects, but merely a marked red coloration. The condition, to which the name *erythropsia* is generally given, has not yet received a satisfactory explanation. It has been ascribed to the dazzling caused by rays of light passing through the coloboma in the iris, or to that along with some fatigue of the retina. As it is met with in other conditions than aphakia and coloboma of the iris, and is not a very common occurrence, it is impossible that these should in themselves be of paramount influence in its production. When it appears after a cataract extraction, it usually does not come on until some time after the operation. It is met with in cases, too, where everything has gone well, and good vision has been obtained.

The influence of fatigue or hyperæsthesia of the retina in giving rise to coloured vision is undoubted. Some poisons which cause nerve fatigue occasionally also give rise to chromatopsia.

Some forms of subjective light sensation are of cerebral origin. One of the most common is that associated with *hemicrania*. It may begin in different ways, and last for a longer or shorter time, usually after prolonged bodily or mental fatigue, or at a time when there is more or less nervous exhaustion from want of food or sleep; it suddenly makes its appearance as a dark spot to one side of the field of vision in both eyes. The dark area slowly increases in size, and after some time becomes bordered by scintillating and often coloured, zigzag, margins of greater or less intensity. The configuration of these margins of light often resembles the angular wavy outline of a fortification, and for this reason Airy gave to the affection, from which he himself suffered, the name of *teichopsia*. The duration of the whole visual disturbance is generally less than half an hour. The appearances fade away from the centre towards the periphery, and are most frequently followed by severe headache, often accompanied by sickness, which lasts for several hours. The central nature of the subjective sensations just described is pretty definitely established by the fact that they may occur,

and indeed this is most frequently the case, in true hemianopic form. This could only be the case when the temporary disturbance, whether vasomotor or of whatever other nature, was situated centrally with respect to the chiasma. It seems probable, though, that when the hemianopic or bilateral character is not marked, the disturbance may in some cases really proceed from the retina. I have occasionally met with eccentric negative scotomata in one eye, which appear to have been the result of attacks of this nature.

Idiopathic night blindness.—If the eyes are subjected continually, day after day, to a more than usually intense light, such as is reflected from the surface of the sea or plains in tropical climates, or from chalk-pits or snow, there is apt to be set up a condition which has been called *idiopathic night blindness*. The condition arises from the illumination of the whole retina by strong irregularly reflected or scattered light; other symptoms—namely, a central scotoma, due probably to coagulation or some other molecular change in the retina—are caused by the direct action of the light from strong sources of illumination, such as the sun or electric arc.

Physiologically there exists a condition in some respects allied to night blindness. Thus, if we suddenly enter a darkened room, after our eyes have been exposed to the full light of the day, we experience at first a much greater difficulty in recognising objects around us than we do after the lapse of some minutes spent in the comparative darkness. What is called an adaptation of the retina takes place gradually, and is longer in attaining its maximum the more intense has been the illumination to which the eyes were previously subjected. The time necessary for complete adaptation is also subject to individual differences, depending, amongst other conditions, on the state of the health.

Idiopathic night blindness is more especially liable to occur if, along with the exposure to strong light, the individual is the subject of some weakness—malnutrition, anæmia, scurvy, etc. And although in much the greater number of cases of idiopathic night blindness the primary exciting cause has been found to be referable to the action of strong light alone, or combined with such conditions as those mentioned, a certain proportion of cases appear to occur as a result of these debilitating circumstances, independently of any abnormal conditions of illumination. Of this nature are the cases described as occurring in women shortly before confinement, and in some cases of cirrhosis of the liver and jaundice.

The affection begins with a condition closely resembling that just described as physiological, but in which the period occupied by the adaptation of the retina is very much prolonged. Eventually the adaptation has not time to become complete before the individual is again subjected to the unfavourable conditions, and thus true night blindness comes to be gradually acquired. The difficulties of vision come on during dusk. In rooms, too, which are illuminated by artificial light, unless the illumination is pretty powerful, only objects directly illuminated by the source of light are seen distinctly, the others being more or less indistinct, according to the severity of the symptoms.

The condition is one of anæsthesia, or torpor, of the retina, which requires an abnormally strong stimulus to awaken its physiological activity. Other symptoms are found at the same time, depending more or less upon the same cause.

The indication for *treatment* is to withhold light, so as to allow the retina time to recover itself; and in complying with this indication it is not necessary to keep the patients in absolute darkness, but merely in considerably subdued light, either by the use of dark spectacles or residence in a darkened room, while at the same time attention should be directed, if necessary, to means calculated to improve the general health. Treatment carried out on these lines is always successful, and usually after a very short time. There appears, however, to be a decided tendency to relapse, which should be guarded against by a prolongation of the treatment after recovery.

In a considerable proportion of cases of idiopathic night blindness there is also a condition of xerosis of the conjunctiva, due to the glare which gives rise to the defect of vision.

Idiopathic night blindness is accompanied by no marked or constant ophthalmoscopic changes. This absence of ophthalmoscopic changes is also generally characteristic of the somewhat rare condition of congenital night blindness, although it is highly probable that it is closely allied to the degenerative change of the retina known as retinitis pigmentosa, although there is not usually any restriction of the field of vision.

There are two distinct retinal end organs, through the medium of which the transformation of physical states into the nervous stimuli leading to vision takes place. One of these merely effects the transformation of energy which gives rise to the perception of light, and is therefore, so to speak, the end organ for the light sense. The other is capable of differentiating the impressions which it receives (or, it may be, the difference of

the impressions formed on the two end organs), so as to lead eventually to a consciousness of the varying intensities and quality of the light rays falling on different parts of the retina, and thus give rise to the sensations of form and colour. What may be called physiological night blindness shows that on exposure to light there is produced a certain degree of exhaustion of the light-sense end organ, so that a certain time has to elapse before it recovers itself sufficiently to be capable of its full delicacy. Abnormal stimuli are capable of very much intensifying the state of exhaustion, and consequently of prolonging the period necessary for recovery. Thus it becomes a mere question of the balance between supply and demand, so that it is evident that an abnormal degree of exhaustion may be occasioned by either an excessive demand on the one hand, or a defective supply on the other. Whenever there is absence or destruction of the retinal pigment cells, be it congenital or the result of inflammatory or degenerative changes, there night blindness is a more or less marked symptom, and this independently of whether other elements of the retina are affected or not.

Muscæ volitantes.—The appearance of shadows in front of the eye may or may not be pathological, according to their nature and the conditions under which they are seen. There are many irregularities in the normal eye which interfere to a slight extent with the passage of the light rays to the retina, and therefore cast shadows on it. These shadows are, however, mostly too faint to be perceived, owing to the small size of the bodies which throw them, compared to the extent of the surface of light from which rays pass through the pupil. The shadow thrown by one point of light is therefore illuminated by the rays proceeding from others. Only such bodies as lie very close to the retina are rendered at all visible by their shadows, and even then are, as a rule, so faint as to escape observation.

Many people notice small faint shadows which they project to different distances in front of their eyes when looking at a uniformly illuminated surface, such as a white cloud or a sheet of white paper. These have different shapes: they are annular, or strung together in beaded chains, or have more the appearance of irregular shreds of tissue. They are not as a rule fixed, so that while following the movements of the eye they are generally observed to change their position as soon as the eye is brought to rest. On looking upwards, for instance, they appear first to be thrown up along with the eye. On this account these small faint shadows are called *muscæ volitantes*. They are

caused by the presence in the vitreous chamber of small portions of tissue, probably in most cases embryonic. The fact that these shreds of tissue throw shadows at all, under ordinary circumstances, shows that they must be at the posterior part of the vitreous. Owing, too, to the free movement of these muscæ, the vitreous must be more or less liquid in the portion occupied by them. As, however, the same muscæ can always be seen over and over again, pretty much at the will of the individual, and differ very little in their faintness, the liquid portion in which they float must be very narrow. When the rays which enter the eye proceed from a luminous source of a very small extent, such as is the case with those which pass through a pin-hole in a card held close in front of the eye, the muscæ appear much darker and more numerous, and other more anteriorly placed irregularities become at the same time visible.

It is not easy to draw the line between what may be looked upon as pathological, in respect to the appearance of muscæ volitantes, and what is merely physiological. With a small pupil and continued fixation, such as is necessary for writing or drawing on strongly illuminated sheets of white paper, etc., the muscæ seldom fail to be observed, though they are more readily seen where there is myopia, and the surface looked at lies beyond the far point. When attention is once drawn to them, they frequently cause considerable annoyance. Yet under such conditions their appearance cannot be considered other than physiological. On the other hand, when the conditions are not specially favourable, and they yet cause more or less constant annoyance, they are an indication of the existence of a hyperæsthetic state of the retina, and as such often of some general disturbance, most frequently in connection with the digestive organs. When numerous and changeable, they point to some degree of liquefaction of the posterior part of the vitreous, and are then often associated with the higher degrees of myopia. As long, however, as the bodies casting the shadows are so small as not to be recognisable on ophthalmoscopic examination, they may be generally diagnosed as mere muscæ. The complaint of anything appearing to float in front of the eye should, however, always lead one to make a proper objective examination.

Colour blindness.—Congenital defects of colour vision occur in from 3 to 4 per cent. of the male population of civilised countries. Amongst females the percentage is enormously much lower, not indeed one-twentieth of that for males. This comparative frequency of defects of colour vision has directed

attention to the possible dangers which might result from the employment in our railways and mercantile fleet of individuals unable to distinguish with certainty between red and green, the colours universally used as signals. Accidents directly traceable to mistakes arising from colour confusion must be of extremely rare occurrence, partly because the two signal colours are not amongst those pairs for which the greatest confusion exists, and partly because the recognition of the signal does not generally depend upon one man alone. The possible dangers have certainly been considerably exaggerated. Still there can be no doubt that a systematic examination of the colour vision of all persons entering these services is desirable.

When the possible dangers in connection with colour blindness were recognised, it became of importance to discover a means whereby any trace of this anomaly could be speedily detected. Holmgren was the first to devise and employ a method which has proved to be thoroughly practical and expeditious. A high degree of achromatopsia may coexist with a tolerably perfect power of naming colours. It is evident, therefore, that any system based on the statements made by individuals as to the names of colours presented to them must be rejected as impracticable. Of course when the test of naming colours can be made under the same conditions in which they are used as signals, it may safely be employed as a means of detecting those who should be disqualified. Holmgren adopted the method of *comparison* between colours which to the normal eye are different.

Holmgren's test for colour blindness. — The individual examined is asked to pick out from amongst a large number of different coloured wools those which appear most like one particular shade placed before him.

From the way in which the test is executed by different individuals, it can at once be seen whether they are colour confusers or not. Those with normal vision, provided they are possessed of a certain amount of intelligence, are not long in selecting the few shades which most nearly resemble the pattern given them to match. A colour confuser, on the other hand, soon makes a sufficient number of mistakes to reveal his defect. Holmgren begins with light green, and when mistakes are made with this, proceeds with some shade of rose—that is, a colour between red and blue. This is very well suited for this purpose, as it can at once be seen, from the colours with which it is confounded, in which direction the defect lies.

What is the actual condition of the sense of colour in those

who are colour blind? In the first place, there can be no doubt that an individual who is blind for one particular hue is at the same time blind for its complement.

Again, although he fails to distinguish between many different colours, yet he is only actually blind for two particular hues which are complementary, and the slightest change in which is capable of giving rise to a colour impression.

Only one neutral line is usually to be found in the spectrum of the colour blind. The reason for this is, that in the immense majority of cases the complementary hue to the green hue for which they are insensitive is not found in the spectrum. It is in fact one of the purplish hues which are invisible as homogeneous light.

If we take any red, orange, yellow, or green sector, and combine the impression received from it with that from a blue pigment by rotation on a disc, we find that the proportions of any of these with the blue, which is necessary to produce a neutral colour sensation, varies in different cases of colour blindness—that is to say, different cases are blind for different non-saturated hues, which, owing to their mixture with white light, are impure, and, owing to the absorption of light by the pigments, are wanting in brightness.

In all probability, therefore, there are a great number of forms of colour blindness, though they bear a close resemblance to each other, corresponding in general to blindness for certain rose and green hues.

The term colour blindness is in such general use that it would seem inadvisable to reject it altogether. Nevertheless, it is obvious that such a term as *colour confusion* would be more applicable to all cases except those of total colour blindness.

We know the primary cause of colour sensations, and the final result. Of the intermediary stages in the process, namely, the manner in which the definite physical conditions become changed into definite psychical impressions, little is known. It is known, of course, that the first transformation takes place in the retina, and that the brain receives the retinal impressions, which are conveyed to it along the optic nerves. But we do not know what is the nature of the transformation that takes place in the retina, or of the resulting primary excitation in the brain which awakens the consciousness of colour. It is natural that there should be speculation as to the manner in which the intermediary process is accomplished. One can readily understand, too, that the fact that it is possible to obtain all colours from three or more colours variously combined, taken along with the

doctrine of specific nerve energies of Johannes Müller, should create a strong leaning towards "fundamental" colour hypotheses. Apart, however, from this, there does not appear to be any reason for making such an assumption; there is, in fact, no evidence of the existence of primary colours either in the physical basis or in the final consciousness of colours; in other words, in all we know anything about.

A question which naturally suggests itself is, Where is the defect in colour blindness? Is it in the retina, in the optic nerve, or in the brain? So far as pathological conditions go, there is never any great disproportion met with between the colour and form sense defects in any case of purely retinal disease—that is to say, disease involving only the percipient layers of the retina; the changes in colour vision to which such alterations give rise are similar to what is caused by diminished illumination: colours are seen much as they are in semi-darkness. On the other hand, colour vision appears to be disproportionately reduced, as compared with vision for form, in all cases where the conducting mechanism is implicated. This is most marked where it may be assumed that there is a general lowering of the conductibility of contiguous groups of optic nerve fibres, as in the various forms of amblyopia affecting the centres of the retina (toxic amblyopia, retrobulbar neuritis). It is in cerebral changes, however, that the greatest proportionate defects in colour vision are found—alterations in the retinal elements and optic nerves produce a lowering of colour perception, not merely red-green confusion, though this, especially in the latter cases, is often most marked, corresponding to the less perfect development of red-green vision at some parts of the normal retina. In the case of changes localised in the brain, this tolerably equal distribution, or impaired vision for all colours, is also what is most frequently met with (in the so-called hemiachromatopsia, for instance), but cases have been recorded in which a purely red-green confusion has been acquired. The experience of pathology would render it probable, then, that the abnormality in colour blindness is a central cerebral one and not retinal, *i.e.*, that the retina of the colour blind responds in the same manner to the ordinary physical stimuli, but that for some reason or other the psychical result is an abnormal one. This is all the more probable from the fact that under altogether normal conditions of colour vision the same physical stimulus does not necessarily give rise to the same colour impression. This is seen in the well-known phenomenon of simultaneous contrast.

Hemianopia.—Symmetrical defects in the fields of vision are

most commonly caused by lesions in the chiasma, the optic tracts, and their more central connections. If the defects lie to the same side in both eyes,—that is, inwards in one and outwards in the other,—the condition is that which is now generally called *homonymous hemianopia.* Homonymous hemianopia may be to the right or left, and partial or complete, just as we have complete and partial, right or left, hemiplegia. It may or may not be associated with hemiplegia. If the case be recent and uncomplicated, there is no appearance of atrophy of the nerves. The line of demarcation between the blind and seeing portions of the field is usually sharp and regular; when the hemianopia is complete, it is a line coinciding (for peripheral portions of the field, at anyrate) nearly, if not exactly, with the vertical through

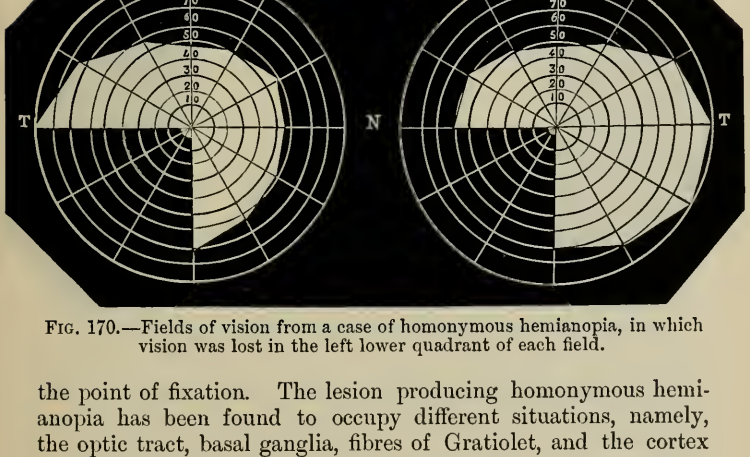


FIG. 170.—Fields of vision from a case of homonymous hemianopia, in which vision was lost in the left lower quadrant of each field.

the point of fixation. The lesion producing homonymous hemianopia has been found to occupy different situations, namely, the optic tract, basal ganglia, fibres of Gratiolet, and the cortex of the brain in the occipital lobe.

The experiments of Munk, and the results of post-mortem examination, have definitely established the existence of an unilateral source of innervation for corresponding halves of both retinæ. In the cases where the lesion has been cortical, it has either been one occupying a portion of the grey matter of the occipital lobe, or one pressing on the white matter with which it is in connection.

Important data in connection with the localising of lesions which have led to hemianopia are afforded by the consideration

of the concomitant symptoms, as well as by the extent and configuration of the blind area. In all the cases which I have seen of so-called hemiachromatopsia,—that is, cases in which the half-blindness appears to be only for colours,—I have been able, by testing with very small white objects at a distance, to demonstrate that the form-sense has also been defective over the same area. Indeed, the results of careful subjective examination in these as in other cases point altogether more to the probability of colour vision being due to a subtle differentiation of light impressions, than to any impression made upon other centres than those in which the consciousness of form is evoked.

When the hemianopia is partial, the defect is generally, though not always, of equal extent in both eyes.

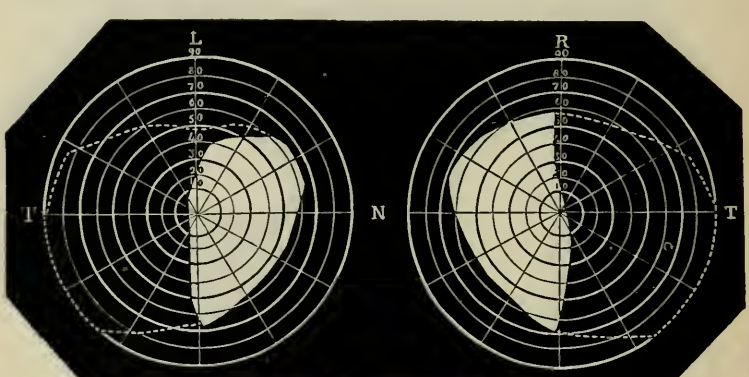


FIG. 171.—Fields of vision from a case of temporal hemianopia.

The hemianopia may in rare instances be limited to corresponding insular portions in the homonymous halves of the two visual fields.

Bi-temporal hemianopia.—The other form in which a half-blindness may present itself is often called crossed hemianopia, though the term bi-temporal is preferable. It is of considerably rarer occurrence than the homonymous form.

The arrangement of the optic nerve fibres renders the localisation of the lesion producing bi-temporal hemianopia a very simple process. The symptoms are always caused by more or less complete destruction of the fibres of the ventral surface of the chiasma. This situation is that occupied by the fibres which cross from the optic nerve of the one side to the optic

tract of the other. Bi-temporal hemianopia is therefore conclusive evidence of disease involving the chiasma.

It is difficult to form any idea of the frequency of this variety of hemianopia. Owing to the nature of the defect, leaving as it does a much larger field for both eyes than the homonymous form, the patient does not as a rule complain of blindness to one side. The other symptoms, too—amblyopia, ophthalmoscopic changes, etc.—are sufficiently marked to engage the whole attention of anyone who does not make a practice of examining the peripheral vision. Besides, comparatively few, no doubt, of the cases which have been observed have been published. Mauthner believes that they constitute about 1 per cent. of all cases of hemianopia, while Förster's estimate is 23 per cent.; the actual percentage probably lies about midway between these extremes. It is obviously a disease of too rare occurrence to furnish even approximately correct statistics from the practice of any single observer, however extensive his experience. A good many cases have come under my own observation, and in three of them the diagnosis—in two cases an aneurysm, and in the remaining one a tumour pressing on the chiasma—was confirmed on post-mortem examination.

The line of demarcation between the blind or defective portion of the field and the normal one is rarely as sharp or as vertical as in the homonymous form. The prognosis is not so good either, most cases going on to complete blindness. Some cases may remain stationary, or recover to some extent. A sudden onset, with subsequent partial recovery, or, as sometimes happens, blindness of one or both eyes followed by temporal hemianopia, is suggestive of an apoplexy in the neighbourhood of the chiasma. A slight degree of intermittence in the symptoms—slight improvement on certain days—is probably indicative of aneurysm. Repeated attacks of bi-temporal blindness, lasting several days at a time, and then recovered from, point, again, to acute intracranial pressure from some cause or other.

SECTION II.

CHAPTER XVII.

ERRORS OF REFRACTION AND ACCOMMODATION.

In considering the eye at rest, and not exerting the power which it has of altering its state of refraction, or, in other words, of *accommodating* for the distance from which rays proceed, many points may be perfectly well explained by looking upon it as consisting of only one dense transparent medium, bounded by only one surface, instead of, as is actually the case, being a very complex organ, with a number of differently refracting media.

When the eye is in a state of rest, and not exerting any of its power of accommodation, *i.e.* when its refracting power is at its lowest, one of three conditions must be represented in every case—(1) The principal focus (or the focus of rays which meet the eye parallel to each other, and therefore the focus of a plane wave disturbance) coincides exactly with the most sensitive portion of the centre of the retina; (2) the principal focus lies in front of the most sensitive portion of the centre of the retina; and (3) the principal focus lies behind the most sensitive point of the centre of the retina. In the first case, the eye is said to be *emmetropic*, in the second *myopic*, and in the third *hypermetropic*; and these conditions of refraction are called respectively *emmetropia*, *myopia*, and *hypermetropia*.

Emmetropia in the true sense is exceedingly rare. Very slight deviations in the direction of either myopia or hypermetropia are common, however; so that the eyes which are *practically* emmetropic are common.

It is evident that as there are three elements on which the state of refraction depends,—namely, the length of the antero-posterior axis of the eye, the curvature of the refracting or dioptric media of the eye, and the refracting power of these media,—the conditions on which myopia or hypermetropia depend might be abnormal conditions of all or any of these elements. As a matter of fact many cases of myopia and hypermetropia

do occur which are wholly or mainly caused by some abnormality in each of these directions. Thus we have *axial* myopia or hypermetropia, due to a too long or too short antero-posterior axis of the eye (Fig. 172); *curvative* myopia or hypermetropia, caused by too great or too little curvature (Fig. 173); and *index* myopia or hypermetropia, as the result of too great or too feeble refracting power.

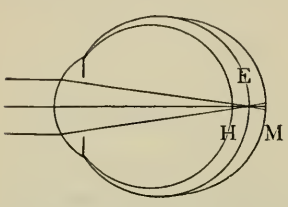


Fig. 172.—Showing the complete focussing of parallel rays in the case of emmetropia, E, and incomplete focussing in hypermetropia, H, and myopia, M.

The emmetropic eye alone, when at rest, is focussed for parallel rays. Rays diverging from a point in front of the eye and suffering the same amount of refraction would meet behind the retina, whilst rays converging to a point behind the eye, and also refracted to the same extent, would meet in front of the retina.

It will be evident now that a myopic eye (*i.e.* one in which the retina lies behind the principal focus of the refracting media) is, in a state of rest, focussed only for rays diverging from some point at a particular finite distance in front of it, and also that a hypermetropic eye (*i.e.* one in which the retina lies in front of the principal focus of the refracting media) is, in a state of rest, focussed only for rays which converge towards a particular point lying at a finite distance behind it.

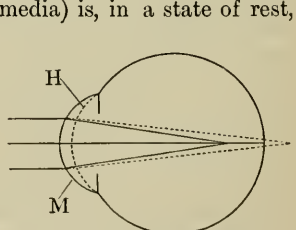


Fig. 173.—Showing the longer refracting power of the more highly curved cornea (continuous line).

Therefore the *static refraction in emmetropia leads to the focussing of parallel rays on the retina, the static refraction in myopia to the focussing of diverging rays on the retina, and the static refraction in hypermetropia to the focussing of converging rays on the retina.*

The greater the divergence or convergence of the rays which is required in any case, in order that they may be focussed on the retina, the greater is evidently the error of refraction. The measurement of that error, or what is called the degree of *ametropia*, is given by the distance from the anterior part of the eye *from* which the rays focussed on the retina *diverge*, or *towards*

which they *converge*. The smaller this distance is, the greater is the ametropia. This distance is also called the distance to the *far point* of the eye. The far point is therefore that point from which rays which meet on the retina of the unaccommodated eye diverge, or to which they converge before entering the eye.

The far point in myopia lies consequently at a *finite* distance *in front* of the eye, whilst in hypermetropia it lies at a *finite* distance *behind* the eye. In the case of emmetropia the far point lies at an *infinite* distance from the eye, because only then are the rays which proceed from a point truly parallel.

Practically, emmetropia is considered to exist in any case where the far point lies not nearer than 6 metres in front of or behind the eye. In the condition of static refraction, then, an emmetropic eye obtains a clear image of objects at a distance.

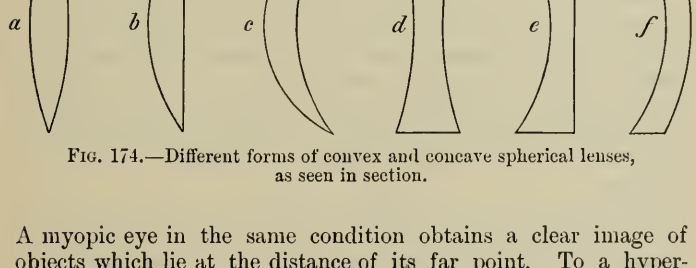


FIG. 174.—Different forms of convex and concave spherical lenses, as seen in section.

A myopic eye in the same condition obtains a clear image of objects which lie at the distance of its far point. To a hypermetropic eye at rest, however, no objects, near or distant, are seen with the utmost degree of clearness, as rays from every real object must diverge, and the hypermetropic eye is only focussed for converging rays.

Spherical lenses.—The substances of which lenses, used for most optical purposes, are made are glass and crystal. Certain names are given to lenses, according to the shape of their two surfaces. When both are convex the lens is called *biconvex*. When both are concave, it is said to be *biconcave*. When one surface is plane, the lens is either *plano-convex* or *plano-concave*. Two other forms of spherical lenses are made, in which the one surface is convex and the other concave, but with different radii of curvature. When the convex surface has the greatest curvature, *i.e.* the smallest radius, the lens is a *convex meniscus* (Fig. 174, *c*);

when the concave surface has the greatest curvature or least radius, the lens is called a *concave meniscus* (Fig. 174, *f*).

The principal focus (the focus of parallel rays) in the case of a convex lens lies on the other side of it from that from which the rays proceed, and is *real*—that is to say, the rays actually are collected; and although, owing to spherical aberration, they do not meet in a mathematical point, still the more axial ones are practically focussed. Convex lenses are therefore called *positive* or *plus* lenses.

The principal focus, again, of a concave lens lies on the same side of the lens as that from which the rays proceed, and is *virtual*—that is to say, the rays do not actually, but only apparently, proceed from the focal point. Concave lenses are therefore called *negative* or *minus* lenses.

Use of spherical lenses in ametropia.—We have seen that in myopia the eye is too powerfully refracting relatively to the position of the retina, *i.e.*, its collecting power is too great. This may be rectified by putting in front of it a concave or negative lens, the strength of which is just sufficient to counteract that portion of the collective power of the refractive media of the eye at rest which is in excess of what is required to focus rays coming from distant points on the retina. On the other hand, in hypermetropia the collecting power of the refracting media of the eye is insufficient, and this again may be corrected by putting in front of the eye at rest a convex or positive lens, the strength of which is just sufficient to supplement the defective amount.

The concave lens which *corrects* the myopia in any particular case, or the convex glass which corrects any particular case of hypermetropia, is that one which, placed at a convenient distance in front of the eye, produces in the state of static refraction of the eye the most accurate focussing of rays from a distant point (parallel rays) on the retina.

The glass in each case must be one whose focal distance equals its distance (measured from its position in front of the eye) from the far point of the eye. It must, therefore, have a shorter focus the nearer the far point lies to the eye. In other words, the higher the ametropia, the stronger must be the correcting lens.

It also follows from the above definition of the correcting glass, that the nearer it lies to the far point of the eye the stronger it must be.

In myopia the far point lies at a finite distance in front of the eye, therefore the strength of a concave glass, in order to correct any definite degree of myopia, must be greater the farther

it is placed from the eye. From this it follows *that the effect of a concave glass of definite strength on myopia is weakened by removing it from, and strengthened by approximating it to, the eye.*

In hypermetropia the far point lies at a finite distance behind the eye, consequently the convex glass which corrects any definite amount of hypermetropia must be weaker the farther it is placed

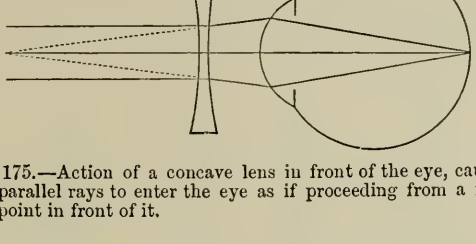


FIG. 175.—Action of a concave lens in front of the eye, causing parallel rays to enter the eye as if proceeding from a finite point in front of it.

from the eye. From this, too, it follows *that the effect of a convex glass of definite strength on hypermetropia is strengthened by removing it from, and weakened by approximating it to, the eye.*

The nature of the correction effected by a lens placed in front of an ametropic eye is therefore to give such a direction to

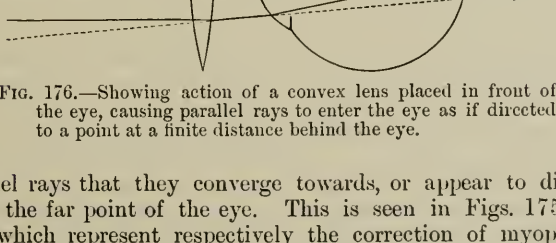


FIG. 176.—Showing action of a convex lens placed in front of the eye, causing parallel rays to enter the eye as if directed to a point at a finite distance behind the eye.

parallel rays that they converge towards, or appear to diverge from, the far point of the eye. This is seen in Figs. 175 and 176, which represent respectively the correction of myopia by means of a concave lens, and of hypermetropia by means of a convex lens.

Numbering of lenses.—Lenses are numbered according to the length of their focus: a focal length, 1 metre, being taken as

the unit, positive or negative. A lens of this power is called a lens of 1 dioptre, or shortly, 1 D. One only half the refracting power of a 1 D lens, and which has therefore a focal distance of 2 metres, is numbered 0·50, and one of twice the power, *i.e.*, with a focal distance of ½ metre, 2·0, or 2 D, and so on.

Lenses used as spectacles seldom require to be stronger than 20 dioptres, positive or negative—that is, 20 times as strong as a +1·0 or −1·0 lens.

Every unit of difference corresponds, then, to an equal increase or decrease in refracting power.

The usual trial cases contain the following spherical lenses, both plus and minus :—

0·25	2·25	5·50	13·0
0·50	2·50	6·0	14·0
0·75	2·75	7·0	15·0
1·0	3·0	8·0	16·0
1·25	3·50	9·0	17·0
1·50	4·0	10·0	18·0
1·75	4·50	11·0	19·0
2·0	5·0	12·0	20·0

In all, sixty-four different spherical lenses. In most cases there are two of each number.

Supposing, now, an eye to be focussed for parallel rays, either owing to its own formation or as the result of an optical correction such as we have considered, it will, when at rest, receive no distinct image of objects near at hand. All that is necessary, however, in order that the retinal image of any object at any distance should be distinct, is that the rays proceeding from it should be given such a direction as if they came from a distance, *i.e.*, that the greater or less divergence of such rays should be converted into parallelism. This could obviously be done by placing a convex lens in front of the eye, the focus of which lens coincided with the position of the object, and whose strength would therefore have to be less the nearer it lay to the eye.

It will now be apparent that should the eye not of itself be so formed as to focus parallel rays on the retina, the glass which renders this possible, and which therefore either diminishes or increases its refractive power, must be subtracted from or added to the lens otherwise required to give a distinct image of an object at any particular distance. Thus, if a myopic individual requires a −2·0 lens to see a distant object distinctly, he will require, as long as the refracting power of the eye remains unaltered, a lens of 4·0 −2·0, or +2·0, to focus distinctly an object at a little more than ¼ metre distant. On the other hand,

a hypermetropic individual who can only see distant objects distinctly with a $+2{\cdot}0$ lens, would require one of $4{\cdot}0+2{\cdot}0$, or $+6{\cdot}0$, to focus an object of a little more than $\frac{1}{4}$ metre distance. *A weaker lens is therefore required for the focussing of near objects in myopia; and a stronger lens in hypermetropia than is required in emmetropia.*

Accommodation.

So far we have supposed the eye to be constantly exhibiting the same degree of refraction, that which results from the relative positions and curvatures of its various refractive media when uninfluenced by any circumstance by which these may be modified. The eye is, however, able by a muscular effort to increase the strength of its refracting power, or, in other words, to *accommodate* itself for the vision of near objects. This is effected by an increase in curvature of the surfaces, and consequent lengthening of the antero-posterior diameter, of the crystalline lens. It is mainly the central portion of the anterior surface whose curvature increases. The effect of this is tantamount to adding a convex meniscus to the crystalline lens, the refractive strength of which meniscus gives the measure of accommodation, so that we talk of 2, 3, 4, 10, or 14 dioptres of accommodation, according to the power of this addition; that is to say, that when, for instance, an eye alters its accommodation from that required for seeing an object at a distance to that required for focussing accurately one at $\frac{1}{10}$ metre, it has altered its power of refraction to exactly the extent which would correspond to the placing of a 10-dioptres glass lens (whose thickness was neglected) immediately in contact with the crystalline lens. The eye is then said to have exerted 10 dioptres of accommodation.

We have seen that the point for which the eye at rest is focussed is called the *far point*. The point, on the other hand, for which the eye is adapted when exerting its full power of accommodation—that is to say, the point which in the strongest state of refraction of the eye has its conjugate focus on the retina—is called the *near* point.

The focal strength, again, of that addition to the lens which brings the adaptation from the far to the near point measures the *amplitude of accommodation* in each case. Thus, if A denote the value in dioptres of the accommodative change, and F and N respectively the values of the lenses in dioptres whose focal distances measured from the eye would coincide with the far and near points of the eye, we have $A = N - F$.

It is evident that equal *amplitudes* of accommodation may coexist with different positions of far and near points. Thus there is the same change in refractive power produced by an addition of 5 dioptres within an eye focussed for parallel rays, as there is by the same addition of 5 dioptres in the case where it is already focussed for a distance of $\frac{1}{5}$ metre. Yet the linear distance between the two points focussed for differs very considerably, reaching, in the first case, from an infinite distance to 20 cms., or 8 in., from the eye; in the second, from 20 cms. to 10 cms., a linear difference of 4 in. In both cases A, the amplitude of accommodation, $= 5{\cdot}0$ in the first, because $N = 5{\cdot}0$ and $F = 0$; and in the second, because $N = 10$ and $F = 5{\cdot}0$.

The accommodation is said to be *positive* when the eye, from being focussed for a more distant object, is adapted for the vision of a *nearer* one; *negative*, when the change in accommodation takes place in the opposite direction, and the refractive power of the eye is diminished. A positive change in accommodation is occasioned by a muscular effort; a negative change, on the other hand, is a result of a cessation of more or less of the muscular contraction, so that the eye in a state of rest, as far as muscular effort is concerned, is focussed for its far point.

The amplitude of accommodation, depending, as it does, on the extent to which the curvature changes take place in the crystalline lens, in response to the action of the ciliary muscle, is influenced by the consistency of the lens substance, as well as by the functional activity of the ciliary muscle or the nerves which supply that muscle. Diminution in the amplitude of accommodation, due to changes which take place in the lens, is physiological in so far as such diminution slowly and gradually takes place during life; probably not beginning, however, till after the first few years of childhood. Although, therefore, not absolutely identical, there exists a very similar amplitude of accommodation in all individuals of the same age, being less the older the individual, until it completely disappears, and no power remains of altering the refraction of the eye.

The linear distance separating the far and near points—or, shortly, *the position of the amplitude of accommodation*—depends, on the other hand, upon the state of refraction of the eye; but it, too, may change with age, owing to the tendency which the condition of refraction has to alter at different times, more especially up to the period of full growth, and after the age of 60.

The most favourable position of the amplitude of accommodation is that which admits of the focussing of objects through the greatest distance. This is what occurs in emmetropia, and in

cases of ametropia where the ametropia is fully corrected. In hypermetropia, when the amplitude of accommodation is considerable, and the hypermetropia not of high degree, it is also favourable, *i.e.*, although a certain portion is required for the adaptation of the eye for distant vision, there still remains a sufficient amount to enable the eye to focus objects at a distance near enough for all practical purposes.

The position of the amplitude of accommodation is most unfavourable in myopia, as in no state of active or passive refraction is it possible for the unaided eye to get properly

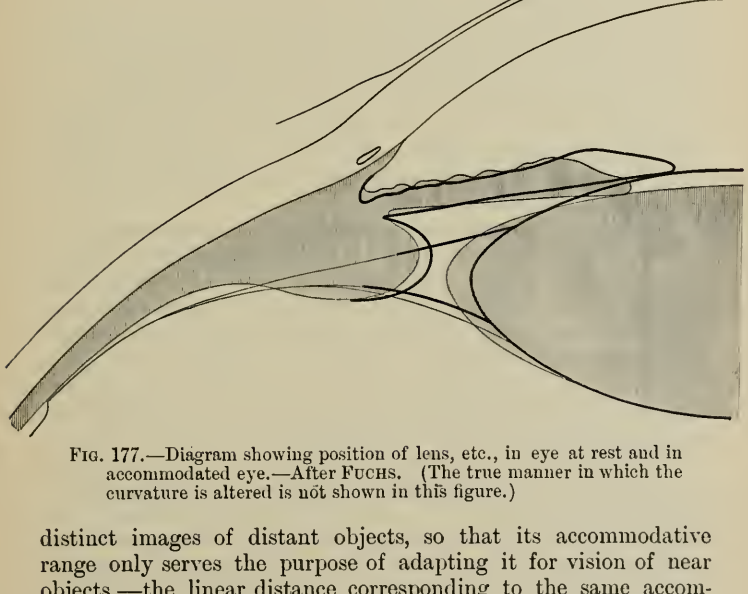


Fig. 177.—Diagram showing position of lens, etc., in eye at rest and in accommodated eye.—After Fuchs. (The true manner in which the curvature is altered is not shown in this figure.)

distinct images of distant objects, so that its accommodative range only serves the purpose of adapting it for vision of near objects,—the linear distance corresponding to the same accommodative range being of course smaller, and consequently less serviceable, the higher the degree of the myopia. Indeed, even when the myopia is by no means considerable, say 4 dioptres in amount, the amplitude of accommodation which the eye possesses is, unless the error be corrected, of little practical use, as few objects require to be looked at, at a shorter distance than $\frac{1}{4}$ metre. Myopia of that degree, at a time of life when there exists an accommodation of say 10 dioptres, is associated with

greater inconvenience, so far as the possibility of receiving distinct images of objects at different distances is concerned, than a hypermetropia of the same degree, and with the same accommodative power, 6 dioptres of which, after 4 dioptres have been employed to adapt the eye for parallel rays, cover the distance from the most distant objects to those only $\frac{1}{6}$ metre from the eye.

It will now be readily understood that more is usually effected by the correction of ametropia than the mere optical adaptation of the unaccommodated eye for the focussing of parallel rays. In all cases where a fair amplitude of accommodation still remains, its position is thereby at the same time displaced, so as to become as favourable as possible.

The contraction of the pupil, which occurs along with efforts at accommodation and convergence of the visual axis, is of more or less service in extending the range of distinct vision. On account of the smallness of the pupil, and consequent diminution in the size of the circles of diffusion, the position at which ordinary sized print, such as that used in newspapers, can be seen, lies considerably within the real near point, or that for which the eye is actually focussed.

The determination of the amplitude of accommodation (A) in a large number of individuals of different ages was made by Donders, who obtained an average for different ages, from which he plotted a curve (Fig. 178) in which the ordinates represent the age and the abscissæ, the corresponding amplitude of accommodation measured in dioptres. This curve enables us to see at a glance what is the average amplitude accommodation for any age, and conversely gives for a certain amplitude of accommodation the average age at which it is found.

The curve gives, too, the actual position of the near point corresponding to any age, supposing the eye to be emmetropic. By merely displacing the curve upwards or downwards, the position of the near point at the same age (and indicated in the same way by the number of the dioptre lens having an equivalent focal length) for any degree of myopia or hypermetropia is obviously also given, as it is clear that this must be got by merely adding or subtracting the value of the far-point lens. Thus in myopia of 5·0 dioptres, according to the diagram at 10 and 20 years of age, the distance of the near point from the eye would be respectively represented by the focal distance of a lens of $14{\cdot}0 + 5{\cdot}0 = 19{\cdot}0$ and $10{\cdot}0 + 5{\cdot}0 = 15{\cdot}0$ dioptres,—*i.e.*, it would be in the first case $\frac{1}{19}$ instead of $\frac{1}{14}$ of a metre distant from the eye (a linear difference of about 19 mm.), and in the

second $\frac{1}{15}$ instead of $\frac{1}{10}$ metre from the eye (a linear difference of over 33 mm.). And whilst in ametropia the near point has usually at about the age of 64 receded so as to be infinitely distant, an individual whose myopia at that age was 5·0 would still have a near point rather within $\frac{1}{5}$ of a metre from the eye.

Again, taking a case of hypermetropia 5·0; we should have the average near point at ten and twenty years represented respectively by lenses $14{\cdot}0 - 5{\cdot}0 = 9{\cdot}0$ and $10{\cdot}0 - 5{\cdot}0 = 5$. Before forty the near point would have receded to infinity, as by that time in emmetropia it is represented by rather less than 5·0,

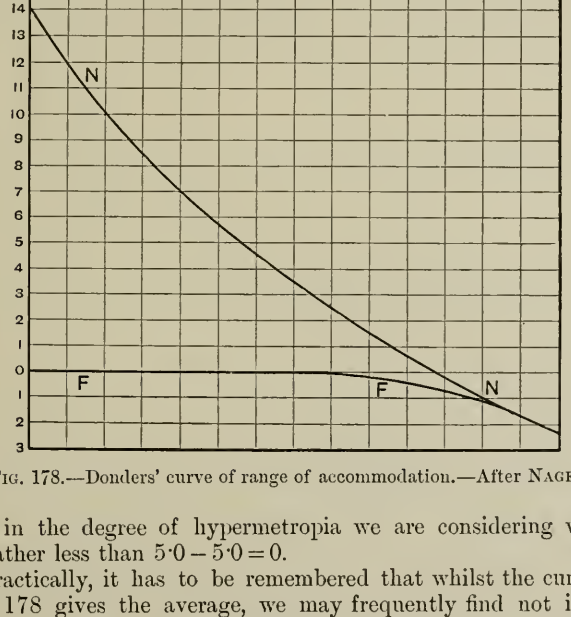


Fig. 178.—Donders' curve of range of accommodation.—After Nagel.

and in the degree of hypermetropia we are considering would be rather less than $5{\cdot}0 - 5{\cdot}0 = 0$.

Practically, it has to be remembered that whilst the curve of Fig. 178 gives the average, we may frequently find not inconsiderable real or apparent differences, more especially in the direction of the range being greater than is there given. It has to be remembered that the near point—and this refers more especially to young people—may not always appear the same in the same case, as much depends on the effort exerted to increase the refractive power, and the greatest possible effort can only be momentarily maintained.

One of the simplest practical methods of finding the position of the near point in any case is to determine the strongest concave glass with which the individual can see distinctly small print (of a size corresponding at a definite distance from the eye to something approaching the limit of his visual acuity); or, where the near point lies beyond the distance at which the print is held, the weakest convex lens with which it can be seen. In order to do so he has, of course, to add as it were an equivalent convex lens to his eye in order to overcome the concave one placed in front of it, so that the strength of that addition, and consequently the point for which the eye is focussed when exerting its full amount of accommodation, *i.e.*, its near point, can be readily calculated from the strength of the concave lens and its distance from the eye. This is seen in Fig. 179, where the meniscus-shaped portion of the

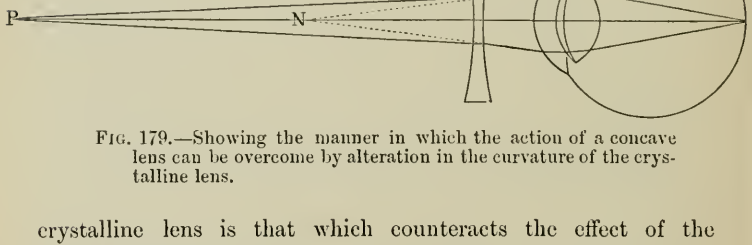


FIG. 179.—Showing the manner in which the action of a concave lens can be overcome by alteration in the curvature of the crystalline lens.

crystalline lens is that which counteracts the effect of the concave lens.

In order to exert the greatest possible amount of accommodative power, most people have to bring about a degree of convergence of their visual axes which is greatly in excess of that which would direct the lines of vision on the nearest point thus accommodated for. What is called the *absolute* near point can therefore, as a rule, only be attained by the sacrifice of binocular vision. The binocular near point and the binocular amplitude of accommodation have been distinguished by Donders from the absolute. It is seldom that the difference between the two amounts to anything of practical importance.

Donders also pointed out the importance of what he has called the *relative* amplitude of accommodation. This may be looked upon as that which is at the disposal of the individual for any particular degree of convergence; that is, given any point on which the visual axes converge, the difference between the

farthest and the nearest point for which the eyes can be accommodated without changing the point of fixation.

The relative amplitude of accommodation varies for different distances of fixation; but the practical importance to be attached to it is usually limited to the amount and disposition of the range which exists for the reading distance. That portion of the relative amplitude which consists of the difference between accommodation for the distance fixed, and the nearest point for which accommodation, with that degree of convergence, is possible, is called the *positive* portion of the relative amplitude of accommodation. That portion, on the other hand, which is the difference between the degree of accommodation for the point fixed and the farthest point which, under the circumstances, can be distinctly focussed for, is called the *negative* portion. The positive portion is determined by the strongest concave glasses which can be overcome, and the negative by the strongest convex glasses which can be overcome without any change in convergence.

It is generally considered that only when the positive portion is at least as great as the negative is the distance one for which accommodation can be maintained for any length of time without giving rise to pain or discomfort, or, in other words, to what is called *accommodative asthenopia*. In some cases, however, there is a considerably greater than normal negative relative accommodative range, so that probably the proportion between the negative and positive portions is of less importance, as affecting the capability of maintaining the necessary degree of accommodation for the working distance, than the actual amount of the positive portion, which should at least equal 2·50 to 3·0 dioptres.

The direction of fixation appears also to be of some influence on the amplitude of relative accommodation. It is not always the same, for instance, in looking down as on looking up at equally distant objects. The difference in this respect is subject, too, to individual variation.

Fig. 180 is Donders' curve of relative accommodation in the case of an emmetrope aged fifteen. The equally distant horizontal lines represent intervals of 1·0 dioptre of accommodation, so that the point where they cut the curve gives the amount in dioptres of accommodation exerted. The vertical lines represent the angles of convergence made by the two visual axes corresponding to the distances for which the eyes are accommodated. The numbering is according to Nagel's metre angle notation, which is based on exactly the same system as that

explained for the metrical numbering of lenses. According to this notation, the angle which the visual axis of each eye makes when a point in the middle line is fixed, with the direction they have when fixing a distant point straight in front of them, is expressed as the reciprocal value of the distance from the eye to the nearer point measured in metres, or fractions of a metre. Thus, if the distance fixed be $\frac{1}{3}$ metre, the convergence is said to be 3 metre angles in amount; if $\frac{1}{10}$ of a metre, distance 10 metre angles; and so on. Similarly, the difference in the degrees

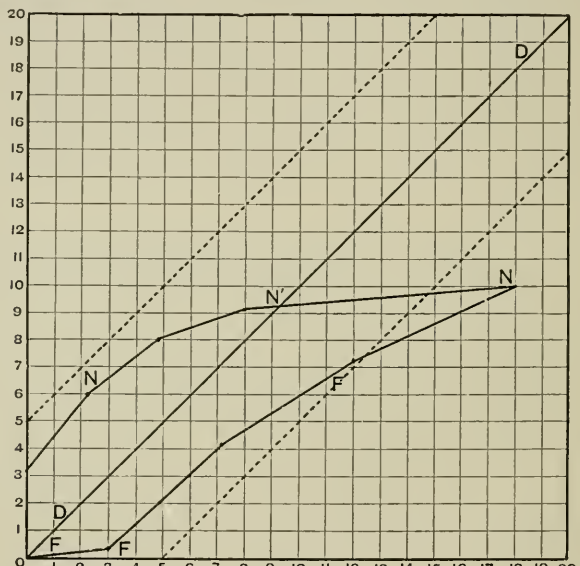


FIG. 180.

of convergence between the direction required for fixation of a point $\frac{1}{3}$ of a metre and another $\frac{1}{10}$ of a metre from each eye equals 7 metre angles.

The normal or ideal relation between convergence and accommodation, in which for any number of dioptres of accommodation exerted a similar number of metre angles of convergence takes place, is represented by the diagonal line. This relation can obviously only exist when the refraction is emmetropic, and the position of rest of the visual axes parallelism, or where a definite degree of hypermetropia or myopia is asso-

ciated with a corresponding amount of divergence or convergence of the axes in the state of rest. The position of any point on the curve above the diagonal represents the positive, that of any point below the diagonal the negative, portion of the relative accommodation for the degree of convergence represented by the vertical line which passes through it. In the case for which the curve is plotted, we see that binocular vision has been impossible for a point N′ lying nearer than between $\frac{1}{9}$ and $\frac{1}{10}$ metre from the eyes, and that although 18-metre angles of convergence were possible, this did not result in an absolute near point closer than $\frac{1}{10}$ metre. The curve also shows that even although it has been impossible to accommodate for the nearest points for which the eyes were converged, still a certain range of relative accommodation remained up to the greatest possible convergence. Here, too, we see that this positive portion of the relative accommodation range has equalled the negative up to a convergence of 5-metre angles, so that the individual has been in the position of being able to maintain the amount of accommodation necessary for reading at $\frac{1}{5}$ of a metre, or say 8 inches, without any inconvenience.

If the myopic or hypermetropic individual were situated exactly as the emmetropic in respect to the association of the convergent and accommodative movements,—that is, if his zero point of convergence corresponded to his zero point of accommodation,—it is evident that when the ametropia was at all considerable he would have to sacrifice binocular vision in order to see distinctly. We have only to displace the diagonal line downwards in the case of myopia, and upwards in the case of hypermetropia, to see at a glance what the requirements of these states of refraction are, and how they become more difficult of attainment, on the supposition made, the higher the degree of ametropia. Thus the lower line represents the requirements of a case of myopia of 5·0 dioptres; it shows that up to a 5-metre angle of convergence no accommodation is required, whilst for 8-metre angles of convergence, for instance, only 3·0 dioptres of accommodation are necessary. Again, a glance at the upper dotted line of the diagram, which represents the requirements of a case of hypermetropia of 5·0 dioptres, will show that up to 5·0 dioptres of accommodative effort the visual axes must remain parallel, whilst for 8·0 dioptres of accommodation only 3-metre angles of convergence are required.

The actual state of matters in cases of ametropia is, however, not so bad as it would be did the conditions as they exist in emmetropia hold good in the manner we have supposed. There

is a great difference in this respect in different cases, a difference which depends partly on the extent to which the nature of the association of the two impulses to convergence and accommodation differs from that which we have looked upon as normal or ideal, and partly on the range of relative accommodation.

A full correction of the ametropia in any case, by which, as we have seen, the position of the amplitude of accommodation is altered to what obtains in emmetropia, frequently gives rise to discomfort, owing to its introducing at the same time a less favourable situation of the existing relation between accommodation and convergence. This is more especially the case when the correction is made in adult life.

On the other hand, a full or partial correction often relieves the asthenopia which an unsuitable relation in the associated impulses occasions.

A question which naturally suggests itself in connection with accommodation is, as to whether or not the two eyes can be accommodated to different extents at the same time. For objects seen in the middle line, and where the refraction is the same in the two eyes, an unequal degree of accommodation would not be required in order that the utmost distinctness of the images on both retinæ should result. On the other hand, when the object fixed is to the one side, and not far from the eyes, or where there is unequal refraction in the two eyes (what is called *anisometropia*), an equal amount of accommodation would obviously not permit of absolutely distinct images being obtained in both eyes. What then happens under these circumstances? Do the two eyes accommodate unequally, so as, when the difference is not too great, an equally distinct image is obtained in each eye? Or do they accommodate to the same extent, and if so, is one properly focussed, or does the accommodation take place in both for an intermediate distance? By holding a weak prism in front of one eye, with the base directed upwards or downwards, whilst a single line of small print or other suitable test-object is fixed either well to the one side, or in the case of anisometropia in front, of the face, it will invariably be found that the image corresponding to the one eye is perfectly distinct, whereas that which belongs to the other is more or less blurred, according to circumstances.

In anisometropia it is usually the eye for which the accommodative effort required for the distance fixed is smallest that is properly focussed. Therefore, when one eye is myopic and the other emmetropic, the myopic one is correctly focussed; when one is emmetropic and the other hypermetropic, the

emmetropic one; and so on. In the fixation of objects lying to one side, it seems generally to be the eye which lies nearest to the object which determines the amount of accommodation to be exerted. In both cases much depends on the state of visual acuity of either eye, and on which of the two retinal images the individual is in the habit of unconsciously directing most attention, but the relation existing between the accommodative and convergent impulses is no doubt also of influence in this respect.

The contraction of the pupil which takes place along with accommodation is a muscular movement associated, in all probability, with both the accommodative and convergent movements.

Presbyopia.

When the near point has receded beyond 22 cms., or a little more (about 9″), which the curve in Fig. 178 shows takes place at or about the age of 45 in emmetropes, a difficulty is experienced in reading small print, more especially when badly illuminated, or in working at anything which requires to be taken near to the eyes in order to give a large enough image to be seen distinctly. To this defect in vision the name of *presbyopia*, or "old sight," is given.

When an individual becomes presbyopic he is obliged to wear convex glasses in order to see distinctly even momentarily anything which he has to take within about 9 inches of his eyes. For objects, too, at a somewhat greater distance from the eyes, corresponding to the ordinary reading distance, he has too small a reserve of accommodative power to continue focussing without undue effort. The glass which has to be worn under these circumstances should be of such a strength as to bring the near point to between 23 and 24 cms. from the eyes, *i.e.*, it should supplement the defect in accommodation to such an extent as to make the combined strength of the accommodative change (measured from the existing adaptation for a distance) and the glass equal to that of a lens of 4·50 placed in front of the eye. In emmetropia, then, it must supplement the amplitude of accommodation by just the amount that it falls short of 4·50 dioptres.

In hypermetropia, although there is for the same age the same average amplitude of accommodation, its position is unfavourable for near vision, and the hypermetrope becomes presbyopic at a time when he possesses a greater amplitude

than 4·50 dioptres, and therefore at an earlier age than is the case in emmetropia.

For myopic individuals the reverse holds good—the position of their range of accommodation is favourable to near vision; the near point is consequently longer in receding to the extent which renders the aid of a convex glass necessary, so that presbyopia is later in making its appearance in myopia than in emmetropia.

From Fig. 178 it will be seen that the originally emmetropic eye becomes, as a rule, more or less hypermetropic after the age of 65; this is represented by the dip of the far-point curve, so that after that age stronger glasses than 4·50 may be required. The cause of this senile hypermetropia is similar to that which gives rise to the advancing diminution in the amplitude of accommodation, namely, the sclerosis of the lens. This produces not only a loss of elasticity, but also a change in the refractive indices of the different layers of the lens. The layers become more and more dense, and eventually equal in their refractive power the central or nuclear portion. The result of this is to diminish the refractive power of the lens as a whole, and therefore of the eye.

The glass required for the correction of the presbyopia in a hypermetropic or myopic individual is at once determined from that required for an emmetrope of the same age by merely adding to or subtracting from it that which corrects the ametropia. Thus, if an emmetrope required + 3·0, a hypermetrope of 2 dioptres of the same age would, as a rule, require + 5·0, and a myope of the same amount + 1·0.

Measurement of Ametropia.

The determination of the degree of myopia or hypermetropia may be made both subjectively and objectively. With a little intelligence and good acuteness of vision, on the part of the individual tested, the subjective method is the most rapid and accurate. It is only, therefore, when either of these factors is deficient, or when the patient tries for any purpose to deceive, that an objective test is called for.

The *subjective test* is made by determining the glass required to give the best vision at a distance. The distance should be at least 5, preferably 6, metres, and the test objects be types or figures graduated in size according to the method first adopted by Snellen.

The presence of accommodative power renders it possible for

people to see equally well (though not so comfortably) with different strengths of glasses. *This circumstance must always be kept in mind whilst making a subjective test under the ordinary conditions.* In order to get rid of the disturbing element of accommodation, many ophthalmic surgeons are in the habit of using a mydriatic. This is an altogether unnecessary inconvenience to which to put the individual examined. It not only unduly prolongs the examination, but often (owing to rays which pass through the more irregular portions of the corneal periphery being included in those which are transmitted through the widely dilated pupil) may lead to a wrong estimation of the refraction. Personally, I have never found it necessary to use a mydriatic for this purpose.

In the case of myopia the degree of normal refraction is given by the *weakest* glass with which the individual obtains his best vision (provided there is not any marked defect in his acuity). Stronger glasses do not necessarily diminish the acuteness of his vision, because they may be, and in the case of young myopes almost invariably are, neutralised or overcome by an accommodative change in the crystalline lens.

In the case of hypermetropia, accommodation plays a still more important part. We have seen that this condition of refraction, when not exceeding in amount the amplitude of accommodation at the disposal of the individual, may be corrected by accommodation. This is, as a rule, what is done, more or less of the amplitude of accommodation being brought into play in order to permit of distinct vision. The desire to see anything distinctly, which is almost constantly present when surrounding objects are sufficiently illuminated, is habitually associated, then, in hypermetropes with an accommodative effort. If, therefore, we put a convex glass in front of the eye, we can only expect to find that with it the hypermetrope, by relaxing a corresponding amount of accommodation, will maintain the same visual acuity which he had without it. *If, then, a convex lens either produces an improvement in vision or does not render distant objects less distinct, the eye must be hypermetropic.*

But we cannot, as a rule, determine the full degree of hypermetropia by means of the convex glass held in front of the eye, in the same way as has been explained can be done with a concave glass in the case of myopia. The reason of this is that the accommodation brought into play in order to overcome the refractive error cannot be altogether relaxed during attempts at fixation, and thus a portion of the hypermetropia remains latent. The *total* degree of hypermetropia (H*t*) is divided then into a

portion which is *latent* (H*l*), and a portion which is *manifest* (H*m*); or H*t* = H*l* + H*m*. The proportion between the latent and manifest portions of the hypermetropia varies with the age of the individual, and also to some extent with the degree of the total hypermetropia. The older the individual the smaller is the proportion which remains latent, so that after a certain age—from 40 to 45—the whole amount is manifest. The lower degrees, too, are more persistently corrected by accommodative efforts than the higher.

The *strongest* glass, therefore, with which the individual retains the full degree of visual acuity which he possesses is the measure of his *manifest hypermetropia*. A determination of the whole hypermetropia subjectively is only possible when the accommodation is paralysed. A close approximation to it may be got by an objective examination.

When the fundus of an eye is illuminated by means of the ophthalmoscope, the rays which are reflected from any point in it proceed after refraction through the dioptric media, as if they diverged from or converged towards some other point, the image of the first. If the eye be hypermetropic, and the defect not corrected by accommodation, they will diverge as if from a point behind the eye; if myopic, they will converge to a point in front of it. The distance of this, the *far point*, measures in either case the degree of the ametropia.

In the emmetropic eye the rays reflected from a point in the retina pass after refraction through the dioptric media, not in the shape of a cone but as a cylinder, all the rays being parallel to the one which passes from the point on the retina to the nodal point. No image of any extent of the fundus of the emmetropic eye is formed in the observer's eye, unless the ophthalmoscope mirror be held very close up to the eye examined. If held any distance off, nothing is seen but a red reflection. The reason of this is that the cylindrical bundles of rays from the points at either extremity of a portion of the retina cross between the eyes of the observer and observed, and thus do not pass through the aperture of the mirror, so that what is seen is merely a collection of rays from a very small area, not sufficiently extensive to be recognised in structure. The larger the pupil of the eye examined the greater is the area from which rays pass into the observer's eye, consequently the larger is the portion of the fundus which he can see at the same time; and, given a definite size of object,—such, for instance, as the optic disc,—the farther away it can be seen.

A distinct image of a portion of the fundus of a myopic eye

is formed in the observer's eye if the ophthalmoscope mirror be held at a distance greater than that of the far point of the myopic eye by at least the distance of the observer's near point. The amount of the fundus whose image is thus seen depends on the size of the pupil and on the degree of the myopia. The larger the pupil the greater the image with a given degree of myopia. Again, the higher the myopia the greater is the portion of the fundus seen with a given size of pupil. When the observer's eye is nearer the eye examined than its far point, it receives rays from a larger portion of the fundus, but, unless his eye be hypermetropic, these do not give the observer a clear image.

A distinct image of a portion of the fundus of a hypermetropic eye is received by an observer reflecting light into the eye from some distance. The amount of the fundus seen depends on his distance from the eye, on the size of the pupil, and the degree of the hypermetropia. It increases as the distance separating the two eyes diminishes, and as the pupil and degree of hypermetropia increase.

If, therefore, the observer at some distance from the eye receives with the ophthalmoscope mirror alone a tolerably clear view of any part of the fundus, such as the vessels or optic disc, the eye examined must be ametropic.

If the patient move the eye slowly in any direction, the image seen will appear to move, and the direction of the movement at once shows whether the fault in refraction is one of myopia or hypermetropia. In myopia the image will move in the same direction as the eyes; in hypermetropia, in the opposite direction.

If, instead of the patient moving his eye, the observer moves his own head, still keeping the fundus in view, then in myopia the image moves in an opposite direction to that of the observer's head, while in hypermetropia it moves in the same direction.

The movement here observed is a parallactic one, due to the position of the images of the fundus with respect to the pupil. As the pupil lies behind the image in myopia, and in front of it in hypermetropia, their apparent movement is in opposite directions, the more distant object always appearing to move with the mirror.

The indications afforded by the mirror alone, or by the indirect method of ophthalmoscopic examination, are only just sufficient to enable one to diagnose whether the refraction is greater or less than normal.

An approximation may be made to the degree of the ametropia in various ways. Two methods are in general use for thus

estimating the refraction, namely, the examination of the fundus oculi with the ophthalmoscope by the direct method and the shadow test.

Objective estimation of refraction by direct ophthalmoscopic examination.—In order to be able to estimate the refraction of another individual, the observer must, in the first place, know the

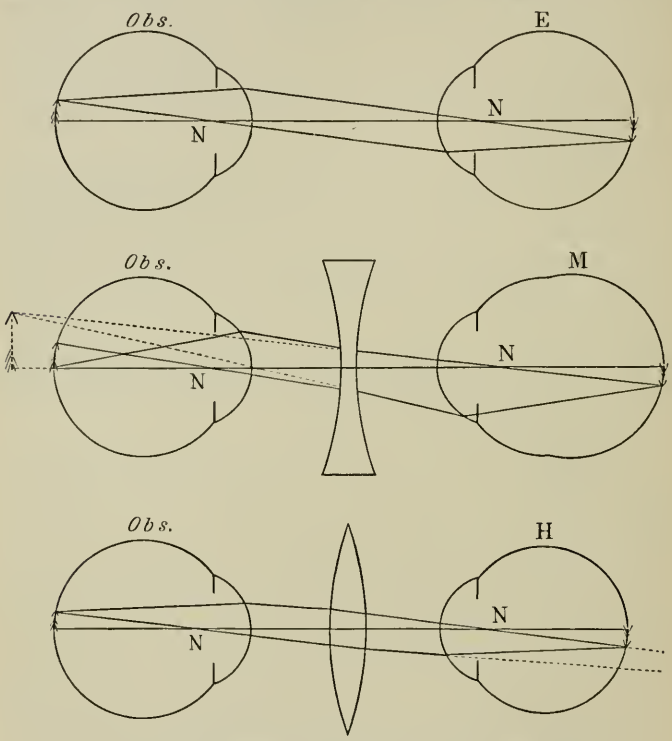


FIG. 181.—To illustrate the estimation of refraction by direct ophthalmoscopic examination.

state of his own refraction. The glass which corrects this, when it is not emmetropic, is brought in front of the aperture of the ophthalmoscope, and forms the starting-point from which any other glass which may be required to obtain a distinct image of the patient's fundus is calculated, as representing the one which in the position which it occupies in front of the patient's eye

approximately corrects his ametropia. Thus, if the details of the fundus appear perfectly distinct to the observer when examining with the ophthalmoscope close up to the patient's eye, the accommodation of both eyes being relaxed, and either without any glass intervening between his own eye and the aperture in the mirror, or with that glass which corrects an existing error in his own refraction, then the patient must be approximately emmetropic, as the rays proceeding from any part of the fundus are then all parallel to that which is directed to the nodal point, and such a parallel bundle of rays must, after refraction through the observer's eye, or through the system of correcting lens and eye, meet at some point on his retina. In Fig. 181, E, the course of the rays is shown in the case of emmetropia of both observer and patient.

When the patient is not emmetropic, it is necessary for the observer, always supposing that he keeps his accommodation relaxed, to bring such a lens behind the ophthalmoscope as shall focus his own eye for the far point of his patient. Thus, if the patient be myopic, he must render his own eye hypermetropic to an equivalent extent, as the rays which meet his eye from any point on the fundus of the patient are convergent instead of parallel, and therefore meet at a point in front of his retina. The concave lens necessary to effect this is that which will correct the patient's myopia, the determination of the degree of which can therefore be made in this way. This is represented at M, Fig. 181.

If the patient be hypermetropic, the observer must bring in front of the ophthalmoscope aperture a convex lens, whose focal distance corresponds to that of the patient's far point, in order that the divergent rays from all points on the patient's retina may be rendered parallel, and thus be brought again to a point on the retina of the observer. The strength of the lens which effects this is, of course, the measure of the degree of the hypermetropia when corrected in the position occupied by it in front of the eye. This is represented in Fig. 181, H.

The estimation of refraction by means of the shadow test is made by observing the direction of motion of the red reflection got by throwing light into the eye from an ophthalmoscope mirror held at some distance and rotated slightly in a definite direction, while lenses of known strength are placed in front of the eye. It has been called the shadow test because attention is directed more to the dark shadow which borders the illuminated area than to the area itself.

The examination is made in the following way. The room

must be darkened. From the source of light—which may be placed either at the side of the patient and shaded from him, or immediately over his head—a beam is reflected by means of an ophthalmoscope mirror. The mirror may be either plane or concave; but, other circumstances being similar, the movements made by the shadow are in opposite directions, according as one or other is used. Thus, if in any case the shadow moves in the same direction as that in which a plane mirror is rotated, it will move in the opposite direction to the rotation of a concave one.

The appearances met with when a concave mirror is employed will be described. The observer should be seated 1 metre from the patient. If, on slightly rotating the mirror, not too quickly, in a horizontal plane, the shadow appears to move in the same direction as the rotation, or "with the mirror," then the refraction is myopic. If it move in the direction opposite to that in which the mirror is rotated, or "against the mirror," the refraction is either emmetropic, hypermetropic, or only slightly myopic. By putting lenses in front of the eye—concave if the direction of the shadow indicates myopia, convex if it indicates hypermetropia—we may arrive at a strength of the lens in either case which reverses the direction of the shadow, and therefore get a first approximation to the lens which is required for the correction of the ametropia, if it exists. The weakest lens which reverses the movement, from being with the mirror to being against the mirror, is not quite the measure of the myopia. On the other hand, the weakest lens which reverses the movement, from being against the mirror to being with it, is rather higher than that required to correct the existing hypermetropia. If the lens is not higher than $+1{\cdot}0$, the refraction cannot be far from emmetropic.

The shadow test has received many names, *e.g.*, keratoscopy, retinoscopy, koroscopy, skiascopy.

Hypermetropia.

This is the most common condition of refraction, and is more common at an early age than in adult life. The eyes of newborn infants are almost invariably hypermetropic. In hypermetropia there is a disproportion between the length of the eye and the curvature of the cornea, and it is not easy to say whether at birth the hypermetropia is an axial or curvature hypermetropia. The hypermetropia which persists after adult life has been attained is, however, almost always axial, and not only is the antero-posterior axis abnormally short, but the whole

eye is often smaller than normal. In the higher degrees, indeed, there appears to be a kind of arrest of development, and this is often associated with a defective visual acuity. The acuity of vision in the lower degrees of hypermetropia is usually normal.

Hypermetropes in whom the defect in refraction is not corrected, are necessarily obliged to exert their power of accommodation more constantly, and to a greater extent, than is the case with emmetropes. This is frequently associated with a feeling of tiredness or pain, mostly referred to the supraciliary region, which comes on when the eyes have been used for a longer or shorter time for reading or other work near at hand, and is known as *accommodative asthenopia*. The circumstances which influence the occurrence and severity of this symptom are—(1) The degree of the hypermetropia; (2) the age of the individual; and (3) the state of the general health. The higher the degree of hypermetropia, so long as there is a possibility of accommodating at all for the distance at which the objects engaging attention are placed, the more likely is there to be asthenopia; and again, with the same degree, troubles are more frequent the older the individual, because the amplitude of accommodation diminishes with age. Difficulties, too, which are overcome without much effort in a state of robust health, give rise to a much more conscious effort in conditions of physical and mental weakness or fatigue; consequently accommodative asthenopia is, *ceteris paribus*, more frequently complained of in the anæmic and delicate than in the robust and active.

When the amplitude of accommodation is much restricted after middle age, or owing to paresis of accommodation, the difficulties of a hypermetrope are increased, as he then not only has a difficulty in seeing distinctly objects near at hand, but has also defective vision for a distance. This condition, in which the hypermetropia is not corrected by accommodation, is called *absolute* hypermetropia.

An apparent divergence of the eyes is often noticeable in hypermetropes. This is due to the visual axis of the hypermetropic eye passing considerably to the inner side of the optic axis.

In a large percentage of cases of convergent strabismus there is found to be hypermetropia. The connection between hypermetropia and convergent squint is explained in the chapter on strabismus. Many hypermetropes only occasionally use their power of accommodation to correct their distant vision, and thus do not constantly keep up the state of contraction of the ciliary muscle. They are in the habit of contenting themselves with

an imperfect image of surrounding objects, unless anything should specially attract their attention.

Owing to the tendency, which exists in by far the greatest proportion of eyes, for the antero-posterior axis to become gradually elongated during the period of growth, an existing hypermetropia is often diminished in degree or converted into emmetropia, and even myopia, by the time an individual has ceased to grow.

The *treatment* of hypermetropia consists in the wearing of convex glasses. The strength required is that which corrects the manifest portion of the hypermetropia. The convex glass chosen is therefore the strongest with which the individual retains the full visual acuity he possesses. If asthenopia be complained of, they should be worn constantly, for a distance and near. When there is no asthenopia, and the hypermetropia not of high degree relatively to the age of the individual, it is generally sufficient, if glasses be used at all, to make use of them for near work. They may then be ordered of a rather greater strength than that which corresponds to the manifest hypermetropia.

Hypermetropes should be seen from time to time, at intervals say of a year, after they have first begun to wear the prescribed glasses, in order to see whether there is any change in the amount of their manifest hypermetropia. In many cases there is none during the years of growing, at anyrate, though as they get older the degree corrected constitutes often more and more of the total amount. In others there is soon found to be a further amount of the hypermetropia which is manifest, and which, when discovered, should be corrected. Again, in some children there is a pretty rapid diminution of the hypermetropia, so that after some time the glasses ordered have become too strong, and weaker ones should be substituted for them.

Hypermetropes have often small pupils, owing to the contraction of the pupil which takes place along with that of the ciliary muscle.

As has already been explained, the hypermetropia which occurs in old age is an *index hypermetropia*, produced by sclerosis in the crystalline lens.

There are no ophthalmoscopic appearances specially characteristic of hypermetropia. Sometimes there is an evident hyperæmia, with some (usually slight) swelling of the optic papillæ. In a small proportion a white crescent is seen to the temporal side of the disc, due to the opening in the choroid, through which the optic nerve passes, being larger than the

sclerotic opening; but this appearance is more frequently associated with the abnormally elongated eye.

Myopia.

Myopia is more frequent, and is met with in higher degrees, in adult life than during the period of growth. It is hardly ever congenital, and usually first makes its appearance after the age of 10. It has a tendency to increase up till the time when the individual is fully grown, after which, in the vast majority of cases, it remains stationary. Progressive myopia, at a later period of life, appears to be more common in women than in men.

Myopia is mostly axial, and though not congenital, the tendency to the elongated shape of the eye is undoubtedly inherited. Except in the higher degrees (above 8 to 9 D) the visual acuity is in most cases normal, and the eye in every respect healthy. The visual acuity for near objects is generally greater in the uncorrected myopic eye than in the accommodated hypermetropic or emmetropic eye.

When uncorrected, the vision for distant objects is indistinct, and the more so the higher the degree of myopia. Uncorrected myopes, however, with the same degree of refractive error, do not by any means see equally badly at a distance, as much depends on the size of the pupil, and more perhaps on the habit, which some possess to a much greater degree than others, of making much out of a bad image. Thus we invariably find that those, otherwise intelligent and observant, who are not in the habit of wearing concave glasses make more of the images—*i.e.*, arrive unconsciously at a more perfect mental elaboration of the images they receive of distant objects—than those who are constantly in the habit of receiving distinct images by the aid of correcting glasses.

The fraction representing the visual acuity is greater, too, the nearer the test object lies to the far point of the eye, and this is most noticeable in cases where the degree of the myopia is only moderate. Thus while V tested at 20 ft. may be only $\frac{1}{10}$, it may be $\frac{1}{8}$ to $\frac{1}{6}$ at 10 ft., and $\frac{1}{6}$ to $\frac{1}{4}$ at 5 ft. *In this way the defective vision caused by myopia differs from amblyopia.*

The pupils in myopia are usually larger than normal, so that the defect of distant vision is in this way increased. The reason of this is, no doubt, the comparative infrequency of innervation to contraction of the ciliary muscle. There being seldom any necessity for it, accommodation is not brought into

play so much as in the case of the other conditions of refraction. The ciliary muscle in myopic eyes is often found to be feebly developed, the circular fibres more especially being conspicuous by their absence.

Myopes have often a sleepy appearance, owing to the imperfect manner in which they see surrounding objects at any distance. For the same reason, there is often a poking of the head forwards, a shyness of character, and a more marked fondness for reading and study than is evinced, on the whole, by those the state of whose refraction enables them to see more distinctly surrounding objects or individuals. Hence in great measure it is that the number of myopes in the learned professions, and amongst those engaged in occupations necessitating near vision, is greater than is to be found amongst those who are otherwise occupied.

There is sometimes an apparent convergent squint in myopes, due to the circumstance that the visual axes then pass slightly to the outer side of the optic axes.

Myopia is sometimes also the result of disease; and when this is the case, it as a rule rapidly assumes a high degree, and often eventually leads to blindness.

In some cases of myopia the absence of accommodative impulses leads to an insufficiency of the power of convergence, which is intimately associated with accommodation. This *insufficiency of convergence* is often wrongly called insufficiency of the interni. The same impediment in the performance of convergent movements is apt, under circumstances of unequal acuity of vision in the two eyes, to give rise to divergent squint, a form of squint more frequently associated with myopia than with other conditions of refraction.

An ophthalmoscopic appearance is met with in the myopic eye, which although not absolutely characteristic of this state of refraction, is more frequently connected with it than with such as are due to a less elongated form of the antero-posterior axis. The appearance is that of a white patch, usually concentric in shape, immediately to the outer side of the entrance of the optic nerve. In some cases it is seen above or below instead of to the temporal side. This patch is due to an absence of some, or all, of the layers of the choroid in this situation, and a consequent reflection of more or less light by the white sclera. Its size bears no invariable relation to the degree of myopia. When large—*i.e.*, when its breadth is nearly equal to or exceeds the diameter of the papilla, and more especially when it extends all round the nerve—it is always associated with the higher degrees,

and must, too, be looked upon as pathological, and suggestive of progressive myopia. The white *myopic crescent*, as it is called, is generally bordered by pigment where it meets with the edge of the normal choroid, and there is often at the same time an appearance of the central vessels of the nerve being pushed to the inner side, an appearance which is due to the edge of the aperture in the choroid coming closer up to the nerve than it does when there is no crescent on the other side.

In many cases of the higher degrees of myopia where the abnormal elongation is due to a staphylomatous protrusion of the back part of the eye, and consequently the myopia is the result of disease, the changes round the nerve are produced not only by displacement of the choroidal aperture, but by degenerative changes of an inflammatory nature as well. At the same time, other changes are met with in the region of the macula lutea. These, notwithstanding the existence of more or less metamorphopsia, *i.e.* the appearance of distortion of objects seen, are at first not very evident, but as the myopia progresses they usually make their appearance as a more or less indefinite irregularity in the retinal pigment layer at the macula, or it may be small whitish or yellowish-white spots in the same region. At later stages a ring-shaped pigmentation, surrounding a more or less degenerated area, is often seen; and in extreme cases actual patches of considerable size may occupy the site of the macula, or the retina immediately surrounding it. In about 10 per cent. of all cases of myopia the condition is met with in one eye alone. In such cases the degree of myopia is rarely more than 4 or 5 dioptres. Occasionally, also, there may be only slight myopia in the one eye, and a much higher, or even excessive, degree in the other.

The *treatment* of myopia consists, in the first place (and in all cases where it is merely a type of refraction, and not the manifestation of any disease), in wearing concave glasses. The glasses worn should, as a rule, be those which fully correct the myopia. Owing to the power of accommodation, stronger glasses than those required do not necessarily render the vision less distinct. The rule is therefore to give the *weakest* concave glasses which admit of the full visual acuity which the individual has.

When prescribed early in life, the correcting glasses may be worn both for distant and near vision without causing any discomfort, and with the advantage of rendering unnecessary the same degree of convergence of the visual axes which the uncorrected myope of any considerable degree is in the habit of exerting when reading. This is not always the case if glasses

are first worn later in life, and it is sometimes necessary, even before the age at which presbyopia shows itself in emmetropes, to use weaker glasses for reading. This is probably owing to the unusual relation which is all at once introduced between the convergent and accommodative movements. Thus, whilst the individual has hitherto been converging up to the distance of his far point without exerting any accommodation, he has now all at once to associate with every degree of convergence a similar degree of accommodation.

The diminishing effect of the concave glasses, which is partly real and partly apparent, though disagreeable at first, generally very soon passes off, and in the lower degrees of myopia is indeed often not noticed at all. The same may be said of the distortion of larger objects to which glasses give rise; indeed, it is most remarkable that so little notice should usually be taken of this.

In progressive myopia due to disease great care should be taken to avoid any undue convergence of the axes—reading in a bad light, exposure to strong light, stooping, etc., anything in fact which might be likely to determine or keep up a congestion of the eyes. At the same time attention should be directed to the general health. Counter-irritation and local blood-letting are also recommended, and may sometimes be of use.

The question as to the *etiology* and pathology of myopia is one of no little difficulty, and one on which many different views are entertained. The greater frequency of this state of refraction in some countries compared with others equally civilised, and the almost complete absence of it in uncivilised countries, has naturally given rise to the idea that it is associated with some of the conditions of civilised life which are more prevalent in some parts than others. No doubt certain circumstances to some extent influence the increase of myopia during the period of growth. Eyes at that time appear to have a tendency to adapt themselves to the conditions under which they are used. The conditions of school life, for instance, are very apt to lead to an increase of an existing myopia, or even to determine this state of refraction in eyes in which the tendency to elongation exists. How exactly this so-called *school myopia* arises has never been satisfactorily explained. But great confusion has been introduced by a failure to discriminate between the cases of short sight due to disease, and those much more numerous cases which are the expression of a particular type, and are no more to be looked upon as pathological than is, for instance, the attainment of a greater than average stature.

The fate of many cases of the malignant forms being assumed as the possible fate of all cases of myopia has given rise to all sorts of theories, supported either by statistics, anatomy, or experiment, to account for the progression which takes place during the period of growth, and to a corresponding number of more or less unpractical proposals as to how such progression is to be stopped. Attention has naturally been directed to schools, from which statistics—mainly from America, Germany, France, and Switzerland—have clearly shown that the percentage of cases, as well as the degree, of short sight increases regularly from the lowest to the highest forms, the increase being greater amongst the children of the better-class schools than amongst charity-school children. Some good has undoubtedly arisen from this agitation, as it has led to much-needed reforms in foreign schools, in the way of better ventilation, better light, better desks, and, more particularly, greater attention being shown to physical training.

Not only have different conditions associated with the use of the eyes at near distances been supposed to give rise to myopia, but many different explanations of the manner in which any particular condition brings about the elongation on which the myopia depends have been advanced. To take but one example: excessive convergence of the visual axes, which is looked upon by many as the main cause of the development and advance of myopia, is by some explained as acting by causing a dragging on the optic nerves; by others, by introducing either increased intra-ocular tension or a stasis in the circulation, resulting from the pressure of the external recti on the eyeballs. Some believe, too, that this may occur without the coexistence of any actual diseased condition of the coats of the eye at the region, which becomes gradually more and more distended; whilst others hold that this is impossible, except on the assumption, for which they find more or less histological evidence, of a low form of inflammatory tissue change. The myopic crescent has often, too, been taken to be the forerunner of a staphyloma posticum, whereas there is good reason to believe that in most cases it is of no pathological importance whatever.

The position of our knowledge with regard to myopia appears to me to be as follows:—We know that this state of refraction comparatively rarely begins much before puberty, that it increases regularly with age till the period of full growth has been arrived at. We know, further, that this increase takes place independently of schooling; and the numerous statistics which have yet been published, though strongly suggestive of a direct

influence of school work on the progression, have by no means clearly established the extent of such an influence. There is no reason why any pathological condition should be inferred in eyes which yield to this influence; as it has been abundantly shown, and is the experience of anyone who has paid attention to this question, that notwithstanding the continuance of the same conditions as to reading, etc., in after life, the rule is for the myopia to remain stationary. The natural conclusion is, then,

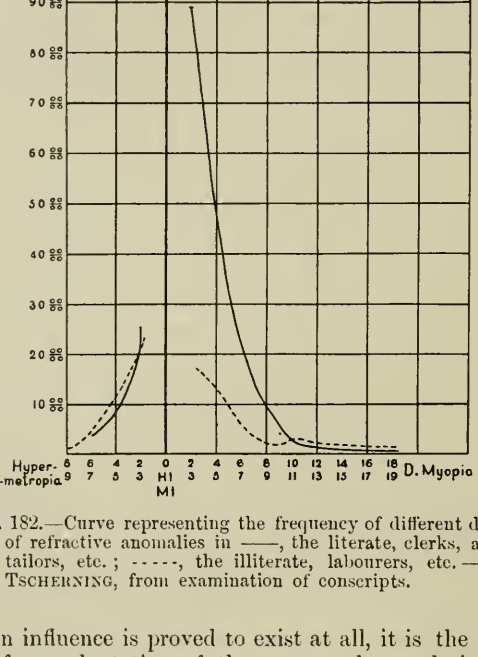


FIG. 182.—Curve representing the frequency of different degrees of refractive anomalies in ——, the literate, clerks, artists, tailors, etc.; - - - - -, the illiterate, labourers, etc. — After TSCHERNING, from examination of conscripts.

that if an influence is proved to exist at all, it is the expression merely of an adaptation of the eye to the work it is mostly called on to perform, occurring at a time of life when such adaptations are possible.

One point of importance is, that although the educated classes present a far larger proportion of myopic individuals than the uneducated, still amongst the latter there is found to be an equally large proportion of the higher and more complicated cases. This is shown diagrammatically in the accompanying

figure. This fact is also an indirect evidence in favour of the ordinary myopia being in no sense a disease.

The malignant form is relatively much rarer than the statistics of any ophthalmic clinic would lead one to suppose, owing to the circumstance that so many myopes of the ordinary type, having no retinal defect, readily find out how to correct their refraction themselves. We find, too, an undoubted hereditary predisposition to ordinary myopia, whereas little or none seems to exist in connection with the malignant form. This heredity is markedly visible in America, where, notwithstanding the subjection to the same conditions of school life, there is a great difference in the percentage of myopes found amongst the children of German, English, or Irish parentage. It appears to be a pretty definitely established rule that those countries which have longest been civilised have the largest proportion of myopes, and that, too, to a large extent independently of whether or not at the present time they are the most advanced in an educational point of view. Evidently, then, the adaptation that has taken place in the eyes to the requirements of civilisation, in the way of early education, has been slow, and probably influenced more by heredity than by individual application. We have no statistics to show in how far the condition of short sight has acted on the choice of a profession, and consequently those which demonstrate the preponderance of myopia in the learned professions are far from being conclusive, as they are generally taken to be, of the influence of study in causing or increasing it. In a society in which the possession of a certain amount of education is a requirement of the higher classes, the ordinary laws of natural selection must be at work, causing a preponderance of myopia in these classes. On the other hand, in savage communities, where so much depends on the possession of good distant vision, the same laws must act towards preventing the perpetuation of, or even actually exterminating, the myopic type. The higher degrees of hypermetropia appear also not to be met with in savage communities. The same law of the survival of the fittest would act against the perpetuation of this type as well.

A considerable difficulty, it must be confessed, is now and then experienced in determining whether, in any particular case, the myopia is to be looked upon as pathological or not, so that it is not always easy to draw a sharp line between the two forms. This is not to be wondered at, as the short sight at the time of examination may be the only symptom of what is actually a disease.

Whatever be the cause of the probable increase in the exist-

ing tendency to progression in myopic eyes during the period of growth, which application of the eyes to near objects produces, there can be little doubt that the proper treatment consists in wearing the correcting lenses. Any operative treatment, such as tenotomy of the external recti, paracentesis of the cornea, sclerotomy, etc., the indication for which rests entirely on theoretical considerations, is altogether unjustifiable in the present state of our knowledge.

Astigmatism.

In the conditions of refraction hitherto discussed, we have seen that the rays proceeding from an external point met, after refraction through the transparent media of the eye, at some other point, or as nearly at a point as the existence of spherical and chromatic aberration admitted; that is to say, the refraction was symmetrical round the optic axis. When this is not the case, the eye is said to be *astigmatic* (ἄ, στίγμα), the name first given to this condition of refraction by Whewell.

Two forms of astigmatism occur. The want of symmetry may be of such a nature that the greatest refraction of the rays takes place in one plane, whilst the least refraction takes place in the plane at right angles to that plane, the refraction in intermediate planes being regularly intermediate in amount (though different in nature). This is what is called *regular astigmatism*. The cause is mostly a difference in the curvature of different meridians of the cornea, a difference which may be congenital or acquired. In highly astigmatic eyes the whole globe appears more or less evidently flattened in one direction, so that the deformity does not exist in the cornea alone. Regular astigmatism admits to a certain extent of optical correction.

When the meridians of greatest and least refraction are not at right angles to each other, there is what is called *irregular astigmatism*. This condition rarely admits of optical correction to any extent, and is caused by an irregularity in the curvature of cornea or lens.

Although the amount of astigmatism is always the same for the same differences in the focal power of the two principal meridians, the character of a regular astigmatism differs according to the position that the foci of rays refracted through the meridians of greatest and least curvature have with respect to the retina. If the focus of either coincides with the layer of percipient elements of the retina, the astigmatism is what is called *simple*. Two forms of *simple astigmatism* occur: (1)

Simple myopic astigmatism, and (2) *simple hypermetropic astigmatism*. In the first, the focus of rays passing through the most highly refracting meridian of the cornea is situated in front of the retina, whilst that of the rays passing through the meridian at right angles coincides with the retina (Fig. 183, A). In the second, the focus of rays passing through the feeblest refracting meridian is somewhere behind the retina, and that of the most highly refracting meridian on the retina (Fig. 183, B).

The astigmatism is *compound* if neither of these foci coincide with the retina. *Compound astigmatism* occurs in three forms.

(1) *Compound myopic astigmatism*, when both the focus of rays through the highest and that through the lowest refracting meridians lie in front of the retina (Fig. 183, C).

(2) *Compound hypermetropic astigmatism*, when these foci are both behind the retina (Fig. 183, D).

(3) *Mixed astigmatism*, when the one focus lies in front and the other behind the retina (Fig. 183, E).

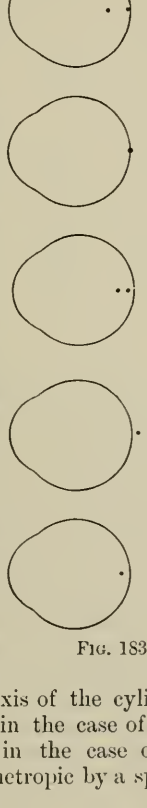


Fig. 183.

The correction of astigmatism is made by means of cylindrical lenses, or lenses which are portions of a cylindrical surface, and in which there is therefore one direction not curved, corresponding to the axis of the cylinder. This direction is the *axis* of the cylindrical lens. The direction at right angles to this is that of greatest curvature, and the only one in which the curve is circular. Fig. 184 shows the plano-cylindrical glass, convex and concave.

For the correction of astigmatism the axis of the cylinder is placed parallel with that meridian which, in the case of simple astigmatism, is emmetropic, and which, in the case of compound astigmatism, has been rendered emmetropic by a spherical lens.

The vision of astigmatic individuals is more or less distinct according to the degree of the astigmatism and the nature of the objects looked at. For ordinary print, for instance, and for

most external objects whose characteristic directions are vertical and horizontal, the direction of the chief meridians makes a difference. If the vision be tested for lines radiating in all directions, it will be found that in simple astigmatism lines parallel to the ametropic meridian can always be seen distinctly. The reason of this is obvious, as the distinct vision of a line mostly depends on the accurate focussing of rays which proceed from every point on it in planes which are at right angles to its direction. In compound hypermetropic and mixed astigmatism, lines in some particular direction can also usually be seen distinctly, owing to one of the meridians being corrected for by accommodation. The lines which appear most indistinct are those at right angles to the clear ones. Sometimes the lines at right angles to the hypermetropic meridian appear most distinct owing to the emmetropic meridian having been rendered myopic, and the hypermetropic meridian emmetropic, by an accommodative change.

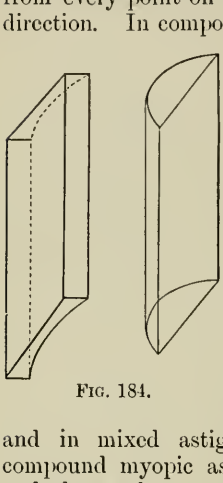


Fig. 184.

The line most distinctly seen in compound hypermetropic astigmatism usually (though not always) corresponds in direction with the most ametropic meridian, and in mixed astigmatism with the myopic meridian. In compound myopic astigmatism no line is seen very distinctly, and the weakest concave glass, which makes one line distinct, is the measure of the amount of myopia in the least myopic meridian, the direction of the line most distinctly seen being that of the more highly myopic meridian.

The manner in which those who are congenitally astigmatic see, is not very easy to understand. By holding a cylindrical lens in front of one's own eye, one may produce a distortion of images pretty similar to that which anyone with the corresponding degree of astigmatism must receive on his retina. The fact, however, of this distortion having always existed makes it impossible for him to be conscious of it. But the curious thing is, that the cylinder correcting the astigmatism rarely produces any appearance of distortion, so that, both with and without correction, objects appear of much the same shape, though blacker or more sharply defined with the correcting glass. The appearance of radiating lines in a fan must be much the same as that produced by holding a cylinder in front of a non-astigmatic eye.

The *diagnosis* of astigmatism may be made both subjectively and objectively. As in the case of the diagnosis of myopia and hypermetropia, the former is the more satisfactory if the patient is at all intelligent, and the visual acuity on correction not much below the normal; but objective methods for the testing of astigmatism are less likely to lead to errors in the estimation of the amount of astigmatism present than in the other conditions of ametropia. Their uncertainty lies more in determining its position, *i.e.*, whether simple, compound, or mixed.

The *subjective test for astigmatism* is best made with cylindrical lenses and Snellen's test types, and, as far as the estimation of its degree goes, is easier and requires less knowledge of the theoretical and clinical aspects of refractive anomalies than the testing of myopia or hypermetropia. The reason of this is, that a cylindrical lens, if not of the proper strength, and not properly situated to correct the astigmatism, does not produce the desired improvement in vision, and is disagreeable owing to the distortion of objects to which it gives rise. On account of the visual disturbance being less in the case of astigmatism than in a similar ametropia of the same degree, one should always begin testing with spherical lenses. When it is found that spherical lenses produce no improvement at all, or only a certain degree of improvement as tested with Snellen's types, we may either proceed at once to try whether any improvement is to be got with cylindrical lenses added to the weakest concave spherical lens which gives the best vision, or the strongest convex one which does not make the vision any worse; or we may determine which of a number of radiating lines are seen most distinctly without any spherical glass, or with the addition of such a glass. In this way the refraction in one of the meridians is obtained, and if the form (Fig. 185) sometimes called "Snellen's rising sun" be used, an indication is afforded at the same time of the extent of visual acuity which the addition of a suitable cylindrical lens may lead one to expect to find. After this cylinder is found, and the position in which its axis has to be placed,—and this must be done by testing with which cylinder the vision is most acute,—we must, by adding a weak convex lens, see whether some of the correction is not made by an accommodative change, and eventually choose the combination of glasses, in a case of compound astigmatism, in which the best vision is got with the weakest concave or strongest convex spherical lens.

A useful *objective* method—by which, however, the existence only, and not the amount, of the astigmatism can be diagnosed

—consists in observing whether the image of the disc alters in shape as the lens used in making an *indirect ophthalmoscopic examination* is withdrawn from or approached to the eye. If it does so, there must be astigmatism. A difference in the state of refraction in different meridians of the eye causes the change in size to take place with different degrees of rapidity in different directions, or, in the case of mixed astigmatism, to increase in one direction and diminish in that at right angles, so that in either case an alteration in shape must take place. It is often convenient to make this qualitative test before proceeding to try the effect of cylinders; or if there be any doubt as to the change of shape on withdrawing the lens, and the papillæ appear oval

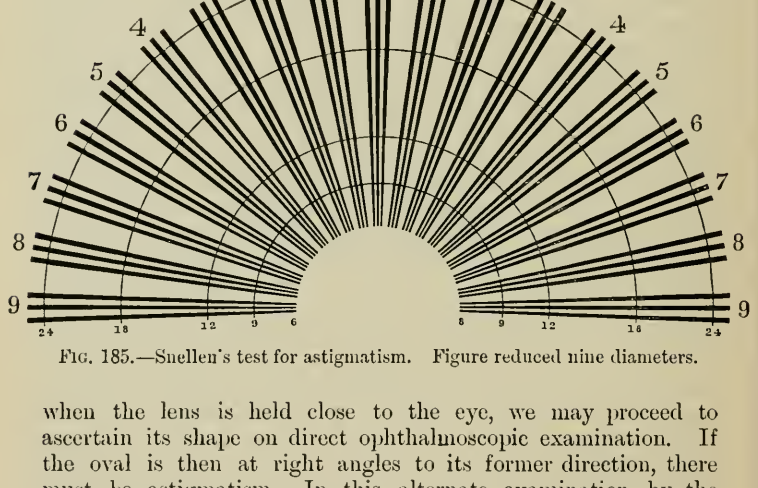


FIG. 185.—Snellen's test for astigmatism. Figure reduced nine diameters.

when the lens is held close to the eye, we may proceed to ascertain its shape on direct ophthalmoscopic examination. If the oval is then at right angles to its former direction, there must be astigmatism. In this alternate examination by the indirect and direct we possess a delicate test for the existence of astigmatism.

However oval a papilla may appear, it is not an indication of astigmatism, unless the shape differs by the direct and indirect methods of ophthalmoscopic examination, or on withdrawing the lens in the latter method of examination.

One of the simplest and best objective tests for astigmatism is made by *retinoscopy*. By noticing with which spherical lens a reversal of the shadow first takes place in one meridian, and

then with which other glass the reversal takes place in the meridian at right angles to the first, which is done by rotating the ophthalmoscope mirror first round one axis and then round that at right angles to it, we are able to determine very approximately the degree of astigmatism. It is evident that the

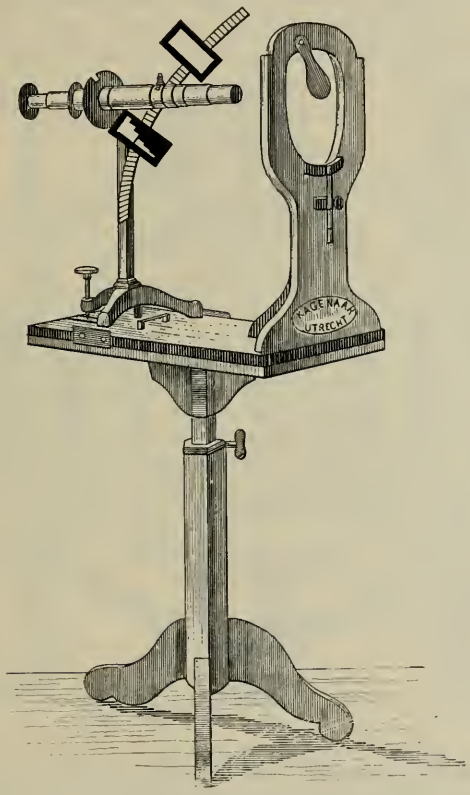


FIG. 186.—Javal's ophthalmometer.

difference in the strength of the lenses which first reverse the shadow in the two directions is the measure of the astigmatism, provided that there has been no change in the amount of accommodation during the examination.

It has already been said that regular astigmatism is mostly due to differences in curvature of the cornea in different direc-

tions. These differences in curvature can be ascertained by means of *Javal's ophthalmometer*, and the astigmatism calculated in this way. This instrument (Fig. 186) consists of a telescope placed horizontally, and so arranged as readily to be directed on the cornea of the eye to be examined. Firmly fixed to the telescope is a graduated arc of 35 cms. radius, the centre of which is in a line with the axis of the telescope, and therefore also with the visual axis of the patient when it coincides with that

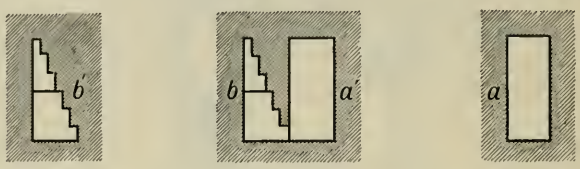


FIG. 187.

of the telescope. On either side of the midpoint of the arc are two movable white figures. These are the objects whose images, on reflection from the cornea, are seen magnified by the telescope. By means of two prisms joined at their apices, suitably placed in the tube of the telescope, the two corneal images are doubled. When the objects are placed at a certain distance apart, one of the images of the one object can then be made to appear to be close up to one of the images of the other object. This is seen in Fig. 187. The distance separating the two objects

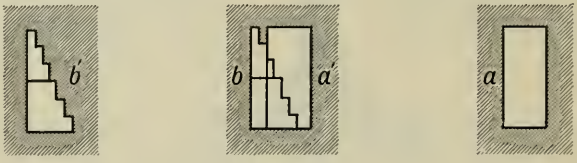


FIG. 188.

which produces this effect will depend upon the curvature of the cornea. Now, if in one position of the arc, say the horizontal, the white objects have been so placed that the one of their corneal images exactly touch, but do not overlap, each other, and it is found that an overlapping takes place when the arc is rotated, so as to take up a position at right angles to its former position, evidence is thus afforded of a difference in the radius of curvature of the cornea in different meridians, *i.e.*, of corneal astigmatism. In Javal's instrument, while the

one object is rectangular the other is so shaped, in steps, that for every step overlapping in the meridian of greatest curvature there corresponds one dioptre of astigmatism. This is shown in Fig. 188, which represents 4 dioptres of corneal astigmatism.

Javal's ophthalmometer, though affording a simple and trustworthy means of calculating the amount of astigmatism, has the disadvantage of being expensive. Placido has devised a simple method, by which, however, only qualitative results are

Fig. 189.—Placido's disc, $\frac{1}{3}$ diameter.

obtained, and the directions of greatest and least curvature shown at a glance. It consists of a piece of cardboard or sheet-tin 8 to 10 in. in diameter, on which a number of alternately black and white concentric circular bands are painted from $\frac{1}{3}$ to $\frac{1}{2}$ an in. in breadth. A small hole is pierced in the centre of the disc, and the apparatus is used in the following way:— The individual to be tested is placed with his back to the window and directed to look at the centre of the disc, which is held in the observer's hand and close up to his own eye, but at a convenient distance, not closer than the observer's near

point, from the eye of the individual examined. The observer sees through the hole in the disc the image of the concentric rings, which, if there be no astigmatism, appear circular. But if the curvature of the cornea is different in different directions, the rings are elliptical in shape, the long axis, or the direction in which the image is largest, corresponding with that of least, the short with that of greatest, corneal curvature. If there be irregular corneal astigmatism, it is very beautifully seen by the use of such a disc. Care must of course be taken, in using Placido's disc, that its plane is at right angles both to the vertical and horizontal planes through the eye.

It is usually the vertical meridian, or some meridian not far from the vertical on either side, which is most curved, and therefore the most myopic or least hypermetropic meridian; but the exceptions to this rule are numerous. Sometimes the ametropic meridians lie at right angles to each other in the two eyes, so that much of the visual defect in either eye is made up for when both eyes are used together. The amount of astigmatism is more frequently different in the two eyes. Though often the same, it is not always exactly so for near as for distant vision. Even when, as is most frequently the case, no appreciable difference in the astigmatism of the unaccommodated or accommodated eye exists, it is not always the cylinder which admits of the best distant vision that is found most suitable for near vision. Many, for instance, and especially if they are over thirty years of age, whose myopic astigmatism is corrected by a concave cylinder, prefer to use a convex one for reading, with the axis at right angles to the position in which the concave one has to be placed. The effect of this is, of course, to render the emmetropic, or more nearly emmetropic, meridian as myopic as the other, and not to neutralise the myopic meridian. The cause of this preference is not always, or even most frequently, connected with a habit of accommodating for a distance at which the rays passing through the meridian of greatest curvature are focussed, as might be supposed, as generally there is a preference given both for distant and near vision for the focussing of lines in the same direction. It is probably due to its introducing a more comfortable relation between accommodation and convergence. Most young individuals with myopic astigmatism seem to prefer, however, concave cylinders both for distant and near work.

The higher degrees of astigmatism (above 4·0 D) are not common. In by far the greatest number of cases which call for correction the amount is from 1·0 to 4·0 D.

From what has been already said, it will readily be understood that the amount of improvement got by cylindrical correction varies very much in different cases, as this depends on the direction of the astigmatism, the intelligence of the individual, and the amount of possible visual acuity in each case.

One effect of cylindrical correction is that the magnification of the retinal image is unequal in the meridians for which the correction is made.

It is no doubt greatly owing to this difference of magnification in different meridians that astigmatic individuals see objects differently on proper correction than they do without correction, *e.g.*, circles appear more or less distinctly elliptical, squares longer in one direction than another, etc.

Regular astigmatism is, as has been said, mainly corneal. The total amount of astigmatism found on a complete subjective examination rarely, however, coincides with that which the measurement of curvature of the principal meridians of the cornea by means of the ophthalmometer enables one to calculate as the degree of corneal astigmatism. There are several reasons for this. One which has been long known, since Thomas Young demonstrated the existence of it in his own eye, is a certain degree of *lenticular astigmatism*. Donders found that the astigmatism due to the crystalline lens generally tended to counteract the corneal astigmatism. It does so when, as is the rule (see p. 480), the vertical meridian of the cornea has the greatest curvature. On the other hand, in corneal astigmatism, contrary to the rule, that caused by the lens leads to an additional amount. For the same reason there may be astigmatism found subjectively where there is a complete absence of corneal astigmatism.

Lenticular astigmatism, whether it be manifest or masked by a contrary corneal astigmatism, is very rarely indeed at all high. It is due to a certain amount of obliquity of the lens, whose axis does not coincide but makes an angle with the visual axis. This angle is greatest in the horizontal plane. Tscherning, who has measured it in a number of eyes, finds that it varies as a rule from 3° to 7°. The astigmatism produced by the greater obliquity is not much more than $\frac{1}{4}$ of a dioptre.

Another circumstance which leads to the corneal astigmatism as estimated by the ophthalmometer not corresponding to the subjective, or what might be called the clinical, degree of astigmatism,—one, too, which is apparently of greater importance than the lenticular astigmatism,—is the irregularity in the amount of curvature at different parts of the cornea. As a consequence

of this, the degree of astigmatism necessarily varies with the size of the pupil. That determined by the ophthalmometer, on the other hand, is the same for the same eye whatever be the size of the pupil, as the reflections from which it is deduced always take place from the same points on the cornea—from small areas not very far removed from, and on either side of, the point at which the visual axis cuts the cornea. The astigmatism as shown by the ophthalmometer is in fact that which would be produced by the differences of curvature of a narrow zonular portion of the cornea (of 2 to 3 mm. in diameter) surrounding the visual axis. The measurements made by Helmholtz and others with the original ophthalmometer led to the conclusion that the surface of the cornea of a non-astigmatic eye was sufficiently approximately an ellipsoid of revolution, while that of an astigmatic eye was ellipsoidal. The calculations which led to this conclusion were based on only a few measurements at different parts of the cornea. As the visual axis was not, as a rule, found to coincide with the antero-posterior axis of the ellipsoid, the angle formed between these two axes received the name angle α. Measurements made by Sulzer with the more easily manipulated ophthalmometer of Javal have clearly shown that the form previously assumed for the cornea is not that which it really presents. With Javal's instrument it is easy to determine the curvature with great accuracy at many different points. The results of Sulzer's examination has been to show that in non-astigmatic eyes the central portion of the cornea is very approximately spheroidal. At about 15°, or on an average 2 mm. from the point at which the cornea is cut by the visual axis, a pretty abrupt increase in its radius of curvature begins to take place. From here onwards towards the periphery the cornea is more nearly ellipsoidal, the eccentricity of the ellipsoid at any point increasing on passing towards the margin. There is further to be found a degree of want of symmetry in the cornea, as there does not appear to be an equal amount of diminution of curvature for equal distances along the two principal meridians, or even for equal distances along the two halves of the same meridian.

The extent to which these peculiarities of shape, which characterise the great majority of corneæ, influence the total degree of astigmatism, as compared with that found with the ophthalmometer, depends upon the size of the pupil, and upon the degree of its decentration. Sulzer found the centre of the pupil situated, as a rule, from 2° to 9°, or on the average 5°, to the temporal side of the visual axis. The usual effect of the

summation of the different degrees of astigmatism at different parts of the pupillary area of the cornea was found to be as follows:—(1) That in eyes which do not show any astigmatism with the ophthalmometer, there is found subjectively a slight degree of astigmatism, contrary to the rule; (2) that in eyes showing with the ophthalmometer a low or moderate amount of ordinary astigmatism, the subjective astigmatism is found to be less, altogether absent, or contrary to the rule, according to the ophthalmometric amount, the degree of corneal asymmetry, the size of the pupil, and the extent of its decentration; (3) that in eyes showing with the ophthalmometer an astigmatism contrary to the rule, there is found subjectively a higher amount of the same variety of astigmatism, owing to the influence of the temporal portions of the cornea for which the astigmatism is more pronounced; and (4) that in eyes showing with the ophthalmometer a high degree of ordinary astigmatism, the subjective astigmatism is often found to be even higher.

Very soon after the ophthalmometer came to be generally used as a clinical instrument, the difference between the degree of total astigmatism as determined subjectively and that found with the ophthalmometer attracted attention. The explanation first given by Javal, and one which seems, notwithstanding its *à priori* improbability, to have received an astonishing amount of support, was that by an irregular or unequal contraction of the ciliary muscle, the lens could be rendered to a certain extent astigmatic, so as in some degree to overcome the corneal astigmatism. Such irregular ciliary contraction is now known not to exist. It has been shown that the differences in question are mainly due to the shape of the cornea itself.

The importance of a consideration of this subject at all, apart from its scientific interest, lies in the practical clinical deductions which have been made on the assumption of the correctness of Javal's explanation. It has been held, for instance, that the supposed irregular contractions of the ciliary muscle, induced in the effort to counteract a corneal astigmatism, are effected with an amount of strain which gives rise to headache and other nervous disturbances, to a tendency to increase of myopia, and even to corneal inflammations.

Headaches due to astigmatism.—The slighter degrees of astigmatism are not unfrequently the indirect cause of headaches. The same irritation which gives rise to headaches from this cause may even, in particularly nervous subjects, cause still more marked neurotic symptoms.

In probably all cases the headaches are due to the summation

of irritation caused by lid-pressure on the cornea. The effect of this pressure is to remove or alter the amount of an existing astigmatism. It is easy to demonstrate, both by subjective tests and by measurement with the ophthalmometer, that slight pressure with the finger is capable of producing very marked changes in corneal curvature. Indeed some astigmatic individuals frequently correct their defect by pressure applied in this way. In the slighter degrees of astigmatism a similar correcting pressure is unconsciously made by the lids. The individual doing so may or may not be conscious of the habit of frowning. It is mostly in the cases of astigmatism "contrary to the rule," *i.e.*, cases in which the horizontal, or approximately horizontal, meridian is the most highly curved that this unconscious lid-pressure correction can be effectively applied. As, too, only the slighter degrees of astigmatism can be modified in this manner, irritation leading, on summation, to headache is practically limited to such cases. At the same time there is frequently also some degree of conjunctival congestion, produced by the pressure.

In all cases in which there are headaches which, from their association with the use of the eyes, are suggestive of having an ocular causation, this astigmatism should be looked for. This is particularly important where there is no hypermetropia to account for the symptoms. It will then often be found that the use of cylinders of 0·5 or 1·0 for reading, with the axes placed vertically if concave or horizontally if convex, will permanently relieve the headaches and remove the symptoms of the conjunctival congestion.

For the same reason, care must always be taken, in giving cylindrical correction for a degree of astigmatism, according to rule, sufficient to cause defective vision, that the correction is not overdone. While vision may be greatly improved by these cylinders, the introduction of even a slight degree of astigmatism in the opposite direction may lead to discomfort, and to the glasses being discarded.

Irregular astigmatism.—A want of symmetry in the curvature of the lenticular or corneal surfaces gives rise to irregular astigmatism. This condition may be either congenital or acquired. The congenital is mostly dependent upon abnormal conditions of the crystalline lens; the acquired form, on the other hand, is mainly the result of alterations in the corneal curvature, caused by cicatricial contractions following inflammations.

The lenticular form, whether congenital or acquired, is often more pronounced for near vision, the defects of the lens

being more marked when it has undergone an accommodative change.

Irregular astigmatism does not admit of optical correction, though many eyes which exhibit this defect are greatly improved by spherical or cylindrical lenses, owing to the coexistence of the more regular anomalies of refraction. Sometimes a stenopaic aperture opposite some particular portion of the cornea effects an improvement.

The diagnosis is readily made by the ophthalmoscope, by the indirect method of examination. On withdrawing or approaching the auxiliary lens to the eye, the papilla is observed to assume various irregular shapes, giving rise to an appearance quite characteristic of this condition. If the irregular astigmatism be corneal, it is beautifully seen by the use of Placido's disc, with which instrument it is easy at the same time to discover the portion of the cornea, if any such portion exists, in which the curvature is least abnormal.

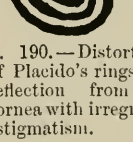


Fig. 190.—Distortion of Placido's rings on reflection from a cornea with irregular astigmatism.

A number of inconveniences are experienced by the wearer of spectacles, some of which depend on the altered physical, others on the altered physiological, conditions which are brought about. Some of the apparent distortions complained of cannot be referred to any physical cause. The altered relation between accommodation and convergent movements, already referred to, often introduces a difficulty when correcting glasses are first used late in adult life. Most of the difficulties experienced on first wearing glasses disappear, however, if the glasses have been properly chosen, and are suitably placed in front of the eyes.

Owing to the prismatic action of the glasses, the field of vision taken in by a concave glass is larger, and at the same time more compressed; that taken in by a convex lens, on the other hand, is smaller and more dispersed than that seen through a simple aperture of the same size as the glasses.

When the same glasses are worn both for a distance and near, they should be centred for distant vision. Reading glasses should be centred for the distance at which they are used, and should be at the same time slightly tilted in their frames, so that instead of being parallel with the face, they come rather nearer it below than above.

A simple method of measuring the interpupillary distance is

by means of Snellen's spectacle frame (Fig. 191), which consists of a pair of plane glasses in an ordinary frame, with a vertical

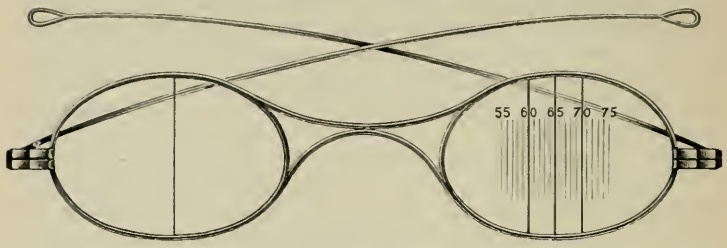


FIG. 191.—(Slightly reduced in size).

line scratched in the centre of one glass, and a number of lines 1 millimetre apart scratched on the other. By putting these

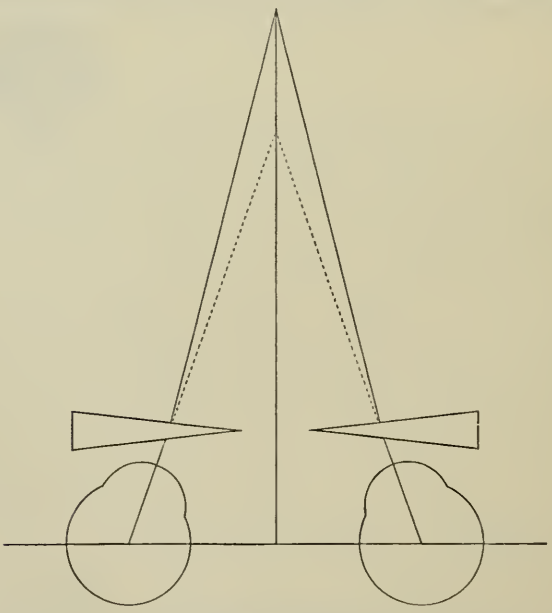


FIG. 192.—Position of prisms causing adduction and diminishing the necessity for abduction.

on the patient's nose, and causing him to look at a distance, and in such a direction that with one's own left eye the line on

the glass opposite his right passes through the centre of his pupil, and then observing which line on the other glass is seen by the right eye (on closing the left) to be opposite the centre of his other pupil, it is easy to measure quickly the inter-pupillary distance with sufficient accuracy for all practical purposes.

Sometimes prisms are used in the form of spectacles, alone, or combined with spherical lenses, in order to ease the movements of convergence or divergence, or, where these movements are

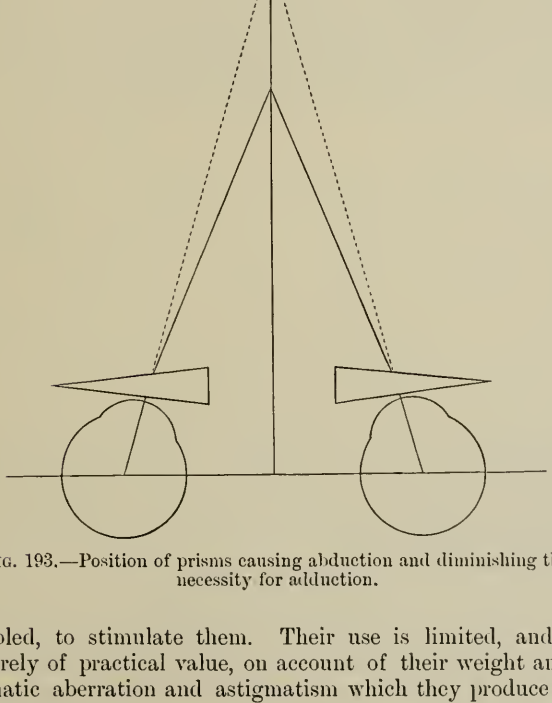


Fig. 193.—Position of prisms causing abduction and diminishing the necessity for adduction.

enfeebled, to stimulate them. Their use is limited, and they are rarely of practical value, on account of their weight and the chromatic aberration and astigmatism which they produce when at all strong.

The action of transparent prisms of greater density than the surrounding medium, and therefore of prisms of glass surrounded by air, is to refract the rays of light which pass through them in such a manner that their direction after refraction is more towards the base of the prism than that in which they are

incident. Prisms with the bases outwards before one or both eyes, therefore, cause objects to appear nearer and smaller, owing to a greater degree of convergence being necessary to bring the rays from them on to both maculæ, than when the prisms are absent. Prisms with their bases inwards, on the other hand, cause objects to appear more distant and larger than they are, owing to the convergence required for their binocular fixation being lessened. Prisms in the former position therefore lessen the strain on divergent movements, and at the same time tend to induce greater convergent movements. Exactly the opposite is the case when they are placed in the latter position. This will be readily understood by a reference to Figs. 192 and 193, the continuous line being the direction of the axial rays from the object, the dotted ones the direction in which they appear to come.

Prisms of 4° in front of each eye are about as strong as can

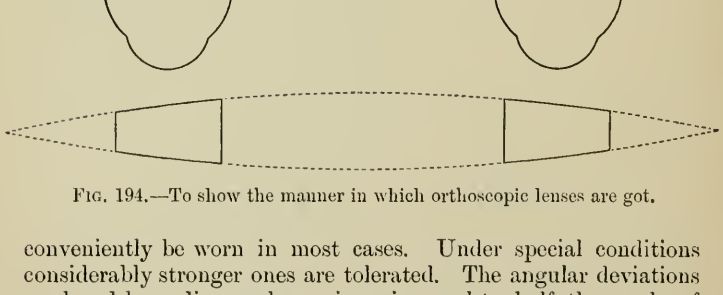


Fig. 194.—To show the manner in which orthoscopic lenses are got.

conveniently be worn in most cases. Under special conditions considerably stronger ones are tolerated. The angular deviations produced by ordinary glass prisms is equal to half the angle of the prism; therefore, with 4° prisms in front of each eye, the deviation amounts to 4° in all.

A decentring of each convex lens to the extent of one-half of the interocular distance gives the same assistance to convergence as it does to accommodation. This effect is produced by orthoscopic lenses, or lenses which are portions of a large lens at distances to either side of its axis equal to half the interocular distance (Fig. 194).

Anomalies of Accommodation.

Reference has already been made to what may be called the passive defects of accommodation, namely, those which depend

upon the absence of a suitable alteration in the curvature of the crystalline lens in response to a definite contractile change in the ciliary muscle. The chief defect of this nature—presbyopia—is physiological, inasmuch as it is a necessary consequence of the manner in which the growth of the lens takes place under normal conditions. In the various dislocations and sub-luxations of the lens we have, on the other hand, the chief causes of pathological passive defects of accommodation.

More active accommodative defects arise from an interference with the function of the ciliary muscle. That muscle may be incapable of contracting at all, or its contractile power may be weakened.

Paralysis of accommodation.—Complete paralysis is almost invariably the result of some lesion of the third nerve. Paresis, on the other hand, may be either a muscular or an innervation weakness.

Associated with complete paralysis we usually find, at all events, paralytic dilatation of the pupil; not infrequently also paralysis of the oculo-motor muscles supplied by the third nerve. These different paralyses are not so often found coexisting with partial paralysis of accommodation. Sometimes, however, there is at the same time a degree of paresis, or even complete paralysis of convergent movement, a movement which is usually associated with active changes of accommodation.

Roughly speaking, the affection which leads to paralysis of accommodation may be either central or peripheral. For instance, the paralysis may be one of the symptoms of all lesions of the brain—injuries, inflammations, tumours—which involve either the trunk or nucleus of the third nerve. Similar affections of the orbit, too, may, by involving some or all of the branches of the third, cause interference with the power of the ciliary muscle. A peripheral neuritis, on the one hand, and disease limited to the accommodation centre, on the other, may be the cause of paresis of accommodation alone.

Two of the most interesting clinical forms of isolated accommodation paralysis are the cases following concussion of the brain and diphtheria. I have seen several cases of more or less pronounced paresis of accommodation after railway accidents. The existence of such a paresis may indeed prove to be the most important evidence of shock sustained. In the case of a woman who was for some months a patient in the Royal Infirmary, almost complete paralysis of accommodation was apparently the only permanent injury resulting from a fall from an express train travelling at the rate of forty-five miles an hour.

Paralysis of accommodation following diphtheria is of pretty common occurrence. It is probably always bilateral, and rarely complete. The paralysis first makes its appearance some weeks after recovery from the diphtheria, at a time, too, when the patient has to a great extent recovered, and seems in other respects in good health. Occasionally it may be associated with other pareses, such as mydriasis, paresis of convergence, paresis of the sixth. Sometimes a concomitant convergent strabismus may exist along with the paresis of accommodation. Of other paralyses, that of the soft palate is much the most frequent.

The most notable feature in connection with the etiology of diphtheritic paresis of accommodation is that no evident relation exists between it and the severity of the preceding throat affection. Often, indeed, that has been so slight as to have been overlooked. It has even been asserted by some writers that the diphtheritic poison may lead to paralysis without having given rise to any local inflammation.

The *prognosis* in diphtheritic paresis of accommodation is more favourable than in paresis of accommodation from almost any other cause. It does not, as a rule, last longer than from four to six weeks.

The *treatment* should consist in giving tonics, especially iron and quinine. Miotics (eserine or pilocarpine), which are usually recommended, are of very doubtful value; possibly, indeed, they may sometimes do harm. I have often prescribed the temporary use of convex glasses of sufficient strength to enable the patient to read in moderation without any strain of accommodation.

Various views have been held as to the cause of diphtheritic paralysis. Probably the pathology of the rarer and less symmetrical paralyses may be different from the more common paralysis of the palate and ciliary muscles. There can be little doubt that post-diphtheritic accommodation paresis, at all events, is due to some toxic action on the brain. The bilateral character of the pareses, its transitory nature, the occasional complication with paresis of other associated movements, are all suggestive of such a cause. Certain products of decomposition, particularly of fish, also cause paralysis of accommodation when absorbed from the alimentary canal. The only apparent difference between the paralysis arising in this way and the post-diphtheritic variety is that the former is more transitory. This probably is simply because the poison is more rapidly eliminated from the body. How the poison producing paralysis after diphtheria is formed, or how it is eventually eliminated, is not known.

Of the toxic effects coming under the notice of the ophthalmic surgeon, that which perhaps most closely resembles diphtheritic paralysis of accommodation is the central amblyopia produced by tobacco (see p. 416). Both with respect to their bilateral character and their slow disappearance, there is a considerable resemblance between these two affections. In both cases it is not certain how the poison acts, whether directly on the centres or indirectly through some localised vasomotor change. In the case of tobacco there is known to be some direct toxic effect on certain nerve cells.

Weakening of accommodation owing to exhaustion of the ciliary muscle is a very frequent result of any severe debilitating illness. Many months may then elapse before the muscle regains its full power, or, at all events, is capable of prolonged efforts of contraction. The same symptom characterises most forms of neurasthenia. The ciliary muscle may be overstrained, too, when prolonged efforts of accommodation are made under adverse conditions, such as the presence of corneal opacities, astigmatism, etc. The amplitude of accommodation may thus be temporarily diminished.

Diminution of accommodation may also be brought about reflexly, and in this way may arise from facial neuralgia, toothache, etc.

Whether partial or complete, the greatest inconvenience from paralysis of accommodation is felt by a hypermetrope, and the least by a myope. In hypermetropia the absence of accommodation causes an indistinctness of distant as well as of near vision. In emmetropia only near vision is interfered with, while in myopia of four or more dioptres the disturbance is so slight that it may remain unnoticed.

It is not difficult to diagnose the presence of complete paralysis of accommodation even in the case of myopia, especially if the myopia admits of good correction.

In addition to innervation and muscular weaknesses, an interference with accommodation may result from inflammatory or atrophic conditions of the ciliary muscle. The most frequent example of this form of paresis is met with in glaucoma, of which affection it is not unfrequently an early symptom.

Spasm of accommodation.—True, persistent spasm of accommodation is either of very rare occurrence or has no real existence at all. I have certainly never met with a case. I have not unfrequently, however, seen cases of so-called spasm of accommodation in which an attempt at seeing distinctly is apt to produce an excessive and unsuitable degree of accommoda-

tion. Such individuals, if emmetropic, are found only to see distinctly at a distance with concave glasses, and may thus be mistaken for myopes. If examined with the ophthalmoscope, the true state of refraction is at once evident. This shows that the spasm is only induced when attention is directed to external objects. A similar contraction of the ciliary muscle takes place, in fact, to that which in a young hypermetrope leads to some of the hypermetropia being latent. The difference between the estimation of the refraction got respectively by a subjective examination and direct ophthalmoscopic examination affords the only means of diagnosing the condition with certainty, unless recourse be had to paralysing the ciliary muscle by the use of atropine. Not unfrequently the temporary spasm may be suspected before an ophthalmoscopic examination is made, owing to the manner in which the patient reads the distant test types. At the moment, if asked to read the smaller letters, he is quite unable to do so, but if he begins the next moment with the larger letters and finally passes through the series, he may momentarily exhibit a far greater visual acuity than he has, as a rule, without concave glasses. Those most liable to suffer in this way are young women whose occupation necessitates constant accommodation for near objects.

CHAPTER XVIII.

AFFECTIONS OF THE OCULO-MOTOR MUSCLES.

Physiological and Introductory.

The eye is freely moved in all directions round a practically fixed point, its *centre of rotation*, by the action of one or more of the six external muscles. The centre of rotation lies about 1 mm. behind the centre of the eye.

The six muscles constitute three antagonistic pairs—(1) The lateral recti (externus and internus), which rotate the eye round a vertical axis; (2) the superior and inferior recti, which rotate the eye round an axis which meets the middle line in front of the eyes at an angle of 63°; (3) the two oblique muscles, which rotate the eye round an axis which meets the middle line behind the eye at an angle of 39° (see Fig. 195). The direction of action of the first pair is lateral; that of the second and third is represented by the figure.

If each muscle were to contract alone, the displacement of the cornea which it would produce would be as follows (see Fig. 196). The externus would displace the cornea outwards, without any torsion, round the antero-posterior axis; the internus would displace the cornea inwards, also without any torsion. The superior rectus would displace the cornea upwards and slightly inwards, and at the same time twist the upper part towards the nose (medial torsion). The inferior rectus would displace the cornea downwards and slightly inwards, and twist the upper part away from the nose (lateral torsion). The superior oblique would displace the cornea downwards and slightly outwards, and produce at the same time medial torsion. The inferior oblique would displace the cornea upwards and slightly outwards, and produce lateral torsion. All the recti muscles tend to pull the eye back into the orbit and are therefore *retractors*. The oblique muscles counteract this by tending to pull the eye forwards. They are *protractor* muscles.

Purely lateral movements are effected by the external and internal recti alone. Purely vertical movements are effected by the combined action of a straight and oblique elevator or depressor. Movements in intermediate directions are effected by the combined action of a lateral and two elevating or depressing muscles.

Purely vertical or purely lateral movements, starting from a position in which the visual axis is directed straight forwards in the horizontal plane (a position which may be called the initial position), bring the eye into what are called *primary positions.*

Movements of the eyes into primary positions take place without any torsion. In the case of purely lateral movements

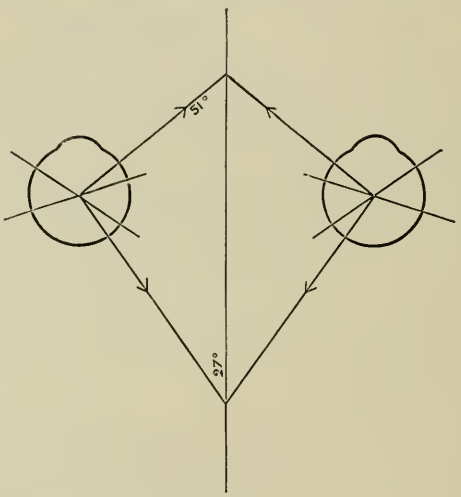


Fig. 195.

the reason of this is obvious; in the purely vertical, it is because the torsional movements of the two elevators or depressors counteract each other. Movements into positions intermediate between purely lateral and purely vertical, or into what are called *secondary positions*, are accompanied by torsion, the direction and extent of which depends on the direction and extent of the lateral and vertical displacement from the initial position. When the eye is *abducted*, or turned away from the nose, the torsional effect of the oblique muscles preponderates; when it is *adducted*, *i.e.*, turned towards the nose, the torsional effect of the recti preponderates. It follows from this—what is found experi-

mentally to be the case—that when both eyes are turned in the same direction into any secondary position, *i.e.* upwards or downwards, to the right or left, the torsion is in the same direction in both eyes,—as one is *add*ucted, the other *ab*ducted,—so that in the one the torsion is lateral and in the other medial.

Associated movements.—The eyes move in association laterally or vertically, or in directions intermediate to these two. These associated movements are so intimate that they may be voluntarily brought about without the aid of any object of fixation. We can at will look to the right or left, or up or down; and we can move the eyes together in these directions even when the eyelids are closed.

According to some, this association is inborn, and the result of stimulation passing to the muscles from definite anatomical centres in the brain. According to others, it is acquired as the result of the habit of binocular fixation. Whatever the cause may be, the association is so intimate that it continues to exist for an indefinite time after any regulation, by the desire for binocular vision, has been rendered impossible from the loss of sight in one eye.

In certain conditions we may find a spasmodic rotation of the eyes in some particular direction, or a more or less complete paresis of associated

FIG. 196.—Diagram showing movement of cornea produced by each muscle separately.

movements. These, however, are the result of cerebral disorder, and not of any defect of binocular vision.

In nystagmus, again, we see associated contractions existing which do not subserve the purposes of binocular fixation.

Perhaps the most noticeable thing in associated lateral movements—and it is mainly with lateral movements that we have to deal in connection with strabismus—is their accuracy. The two associated muscles evidently receive equal impulses to contraction. We have evidence of the same equality of impulse conveyed to two separate muscles in the case of the ciliary muscles, which are incapable of unequal contraction. When, from paralysis or any mechanical cause, the eye cannot be rotated in some particular direction, in accordance with the impulse which the muscle receives in order to effect such rotation, the amount of impulse conveyed is nevertheless shown by the extent to which the associated muscle contracts, so as to move the other eye in the same direction. Under these circumstances, then, the greater the impulse the greater is the deviation of the faulty eye from the direction of fixation.

Any defect in the muscular response to a nerve impulse, unless it be of exactly the same degree in two muscles which usually act in association, must interfere with the accuracy of the associations, and therefore lead to the relative directions of the lines of vision of the two eyes differing for different directions of fixation.

The greatest possible movement of the eyes takes place downwards, and the least upwards.

Convergence.—Besides associated movements in similar directions, we have to consider movements of convergence in which the two eyes are associated in movements which take place in opposite directions. There is good reason, too, for believing that the impulse leading to convergence is equally distributed over the two internal recti. Convergent movements are not, however, so readily induced, independently of any object of fixation, as are similarly directed movements. It is not easy for anyone to converge, on being told to do so, without having any object to converge on, although with practice it can be done. Convergent movements, further, may become greatly enfeebled, or altogether cease, simply as the result of more or less disuse, and without there being any abnormal condition of the central nervous system to account for this. It is important to remember, too, that in all cases in which impulses to convergence are absent, a manifest divergence of the ocular axes is the result. There is only one exception, namely, where there is produced, as the

result of some cerebral disorder, *e.g.* after diphtheria, more or less complete temporary paresis of convergence. But here, no doubt, the tonic element of convergence innervation remains unimpaired.

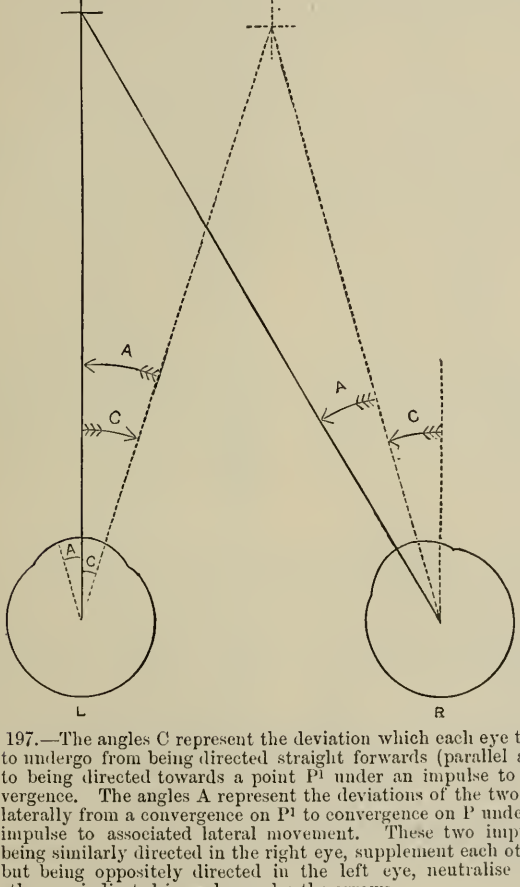


FIG. 197.—The angles C represent the deviation which each eye tends to undergo from being directed straight forwards (parallel axes) to being directed towards a point P^1 under an impulse to convergence. The angles A represent the deviations of the two eyes laterally from a convergence on P^1 to convergence on P under an impulse to associated lateral movement. These two impulses being similarly directed in the right eye, supplement each other; but being oppositely directed in the left eye, neutralise each other, as indicated in each case by the arrows.

Convergence is also associated with accommodation, *i.e.*, when the two internal recti act simultaneously there is more or less tendency to an associated action of both ciliary muscles.

Combined movements, associated and convergent.—The two associated movements, similarly directed and opposed, may be combined. We are able, for instance, to maintain the fixation of a near object, moved from side to side, with no greater difficulty than we do for one at a distance, when the two eye axes are parallel. Take, for instance, the case of a near object placed directly in front of one eye. What impulses lead to its fixation by the two eyes? They are two. First, an impulse to convergence equally distributed over the two interni, and which would produce a convergence towards a point at the same distance as that actually fixed, and placed midway between the eyes; and, secondly, an impulse to associated lateral movements, equally distributed between the internus of the one side and the externus of the other side. This is represented in Fig. 197.

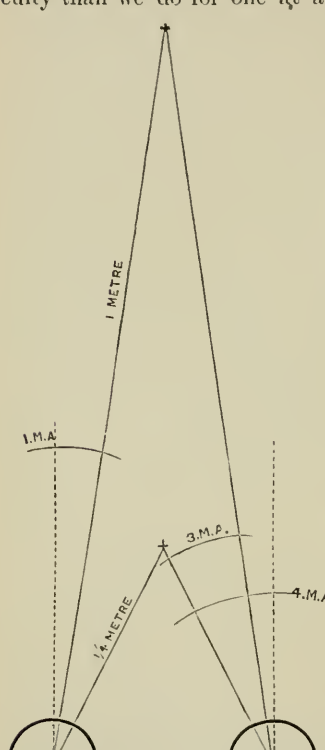


FIG. 198.—To show diagrammatically the measurement of convergence in metre-angles.

Accommodation and convergence.—Whilst there is no doubt that an association exists between accommodation and convergence, it is by no means easy to determine what is its exact nature. And this not only with reference to the starting-point in the brain of the simultaneous impulses to convergence and accommodation, but more particularly to the intimacy of the association. As in the case of the other associated impulses, that conveyed to the two ciliary muscles and those which control the simultaneous similarly directed and opposite movements of the two eyes, it might seem reasonable to infer that the impulses to convergence and accommodation are coextensive. That is to say, that for every unit of impulse towards accommodative change there should be a corresponding unit of impulse to convergence.

The unit of accommodation is the dioptre. Thus when the eye, from being accommodated for a distant point, becomes accommodated for one at a distance from it of 1 metre ($39\frac{1}{3}$, or roughly, 40 English inches), there has been a change effected to the extent of 1 dioptre. The same change again takes place when, from accommodation for the distance of 1 metre, or $\frac{1}{2}$ a metre, or $\frac{1}{3}$ of a metre, accommodation is altered to that for $\frac{1}{2}$ metre, $\frac{1}{3}$ metre, and $\frac{1}{4}$ metre respectively.

In the same way the corresponding unit of convergence is the metre-angle, or the angular deviation of both eyes towards the middle line, when, from fixing a distant object with their axes parallel, the eyes converge upon one placed at a distance of 1 metre from each; or the deviation which occurs when, starting from the fixation of an object at 1 metre, or $\frac{1}{2}$ metre's distance,

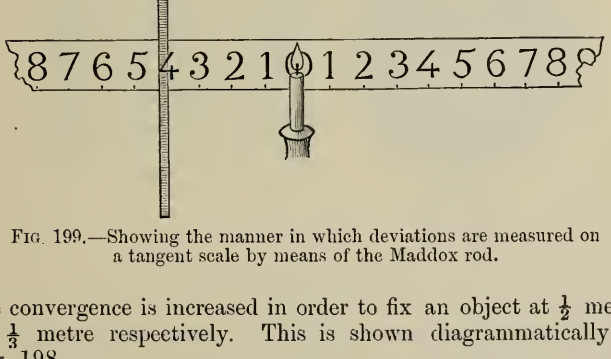


FIG. 199.—Showing the manner in which deviations are measured on a tangent scale by means of the Maddox rod.

the convergence is increased in order to fix an object at $\frac{1}{2}$ metre or $\frac{1}{3}$ metre respectively. This is shown diagrammatically in Fig. 198.

The manner in which the relation between convergence and accommodation may be tested practically is by causing the patient to fix with one eye an object at about 10 in. or $\frac{1}{4}$ metre from the eye, while the observer's hand is held in front of the other eye; on then removing the hand after ten or twenty seconds, the previously occluded eye either makes a movement inwards or outwards, or remains in the position it assumed behind the occluding hand. If after removing the hand a movement of the eye takes place inwards, it shows that it was diverging, if outwards, converging, relatively to the direction it should have. It is important, in making this test, to make sure that the uncovered eye is accurately accommodated for the

object fixed. To discover the position of innervation equilibrium, independent of any accommodative impulse, all that is required, in the case of emmetropia and myopia, is to examine in the same way, only that, instead of fixing a near object, the uncovered eye is caused to fix a distant one. When there is hypermetropia, an approach to the actual condition may be made, greater or less according to circumstances, by correcting the hypermetropia before making the test; but even when the total hypermetropia is corrected after the use of atropine, there may still remain a certain degree of convergence, brought into play by an *impulse* to accommodation.

It is sometimes desirable, however, to make more precise and more definitely quantitative measurements of latent deviations; and to do this, on distant fixation, a very simple and easily

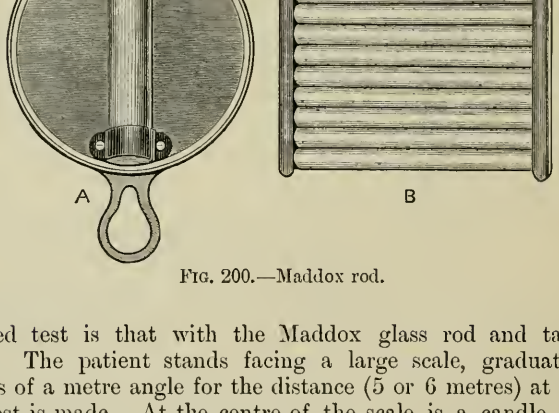


Fig. 200.—Maddox rod.

applied test is that with the Maddox glass rod and tangent scale. The patient stands facing a large scale, graduated in tenths of a metre angle for the distance (5 or 6 metres) at which the test is made. At the centre of the scale is a candle flame. This is fixed by the one eye. In front of the other a cylindrical rod, of 5 to 6 mm. in diameter, of clear red glass is held horizontally. The effect of this is to present to that eye a long vertical red-line image of the candle flame. If there be no latent lateral deviation of the eyes, this linear image appears to pass through the centre of the flame. The existence of a lateral deviation, on the other hand, causes the line of light to appear to cut the scale at some distance—which can be easily read on the scale—to one side or other of the flame. Fig. 200, A, shows the rod fixed opposite a slit in a small metal screen, which pre-

vents any object being seen by the eye in front of which it is held except the elongated image of the flame. Fig. 200, B, shows another arrangement, consisting of a number of rods, by which the same effect is obtained without any difficulty in bringing the cylinder opposite the pupil. Fig. 199 shows the manner in which the line of light is projected on the tangent scale.

For the accurate measurement of deviations at nearer distances of fixation the method introduced by Maddox, with a tangent scale and a prism of 10°, placed base upwards in front of the non-fixing eye, may be most conveniently adopted. Fig. 201 shows a portion of a scale graduated in metre angles for a fixation distance of $\frac{1}{4}$ of a metre,—a distance corresponding sufficiently to the ordinary reading distance; when the scale is held in front of the patient at the proper distance, and the central or zero point fixed, the lower arrow, *i.e.*, the false image caused by the prism, points to the number on the scale which indicates the

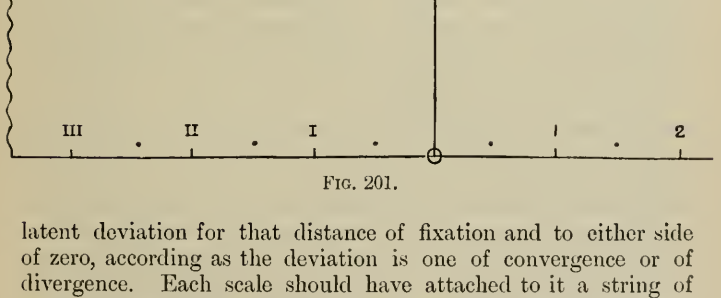


FIG. 201.

latent deviation for that distance of fixation and to either side of zero, according as the deviation is one of convergence or of divergence. Each scale should have attached to it a string of such a length that when the free end is held by the finger of the individual examined against his own temple, the distance at which the scale should be used is obtained by keeping it stretched. A line of small print is introduced below the scale, with the object of securing accurate accommodation, a matter of the utmost importance in making measurements from which any deductions as to existing relations between accommodation and convergence are to be drawn.

For measuring vertical deviations on distant fixation the glass rod and a vertical scale graduated in degrees, with a small flame at the zero point, is most convenient. The metre-angle scale has, of course, only a *raison d'être* in connection with lateral deviations.

The ideal connection between accommodation and convergence is such, that for every dioptre of accommodation there shall be a metre-angle of convergence. This is actually what takes place on binocular fixation in the case of emmetropic eyes. Where an object, say at $\frac{1}{4}$ metre (or about 10 in.), is fixed so as to be seen with the greatest possible distinctness, there is required an accommodation of 4 dioptres, and at the same time there is a convergence of 4 metre-angles. In order, however, that there should be an evidence of association between the accommodative effort and the convergent one, this position of convergence should also be maintained in the absence of binocular vision, or when the one eye is occluded from fixation. Under such conditions, then, it is found that the 4 metre-angles of convergence may or may not be retained; that is to say, that the occluded eye may or may not remain in the same position as it occupied when both eyes were allowed to maintain fixation. More often it does not; and when it deviates outwards (or, in other words, when there is a relative latent divergence), we might still suppose that there was an impulse to convergence coextensive with, and associated with, the impulse to accommodation, but that the actual defect in the amount of convergence seen was due to the starting-point for convergence being a state not of parallelism of the axes but of divergence.

But let us see what takes place in other states of refraction. In the case of myopia of 4 dioptres, fixation of an object at $\frac{1}{4}$ metre from the eyes takes place without any accommodation, whilst the interests of binocular vision necessitate 4 metre-angles of convergence (starting from parallelism). On occlusion of one eye, binocular vision being abolished, and there being no accommodative impulse to carry along with it an impulse to convergence, one might expect to find an outward deviation to the extent of at least 4 metre-angles. In point of fact, whilst one does find more frequent and more marked relative latent divergence in myopes than in emmetropes, it is rare to find, in moderate degrees of myopia, the divergence anything approaching in amount that which would indicate such an ideal association between accommodative and convergent impulses as we have assumed might be expected to exist. In cases of myopia, then, with the impulse to convergence which is excited by the desire for binocular vision, as well as that which would be associated with accommodation, both cut off, there must be some other factor present which leads to the retention of all or most of the convergence. But let us turn to the case of hypermetropia.

A hypermetrope of 4 dioptres must, in order to see distinctly at a distance, accommodate to the extent of 4 dioptres. To see distinctly at $\frac{1}{4}$ metre he must accommodate to the extent of 4 dioptres more. Therefore, on binocular fixation of a point at $\frac{1}{4}$ metre distance, while he accommodates 8 dioptres, he converges only 4 metre-angles. But what of the latent position? If the assumed ideal relation between accommodative and convergent impulses were to show itself, we should expect to find, on occluding the one eye, that the convergence increased to 8 metre-angles. In other words, there should be a large latent relative convergence. Here again, however, the actual experiment gives little or no evidence of this assumed association. No doubt a relative latent convergence is more frequently met with in hypermetropes than in either emmetropes or myopes, but in amount it almost invariably falls far short of that which would indicate so intimate an association between the two impulses under consideration.

There must, then, either be no such intimate association, or it is masked by some other factor which tends to maintain much the same degree of convergence as that which subserves the purpose of binocular fixation when both eyes are free. It is of course possible, as has already been said, that convergent movement may start from a position of absolute divergence of the ocular axes, not from one of parallelism. Yet as we have seen how little the relative latent position on near fixation in emmetropia and myopia is in accordance with this supposition, it is more than probable that it is not this which causes the degree of convergence to remain so approximately equal to the required amount for binocular fixation, whatever be the state of refraction.

Latent positions.—Another point which has to be investigated is the latent position of the eyes for distant fixation. It is often assumed that this latent position—that is, the position taken up in the temporary absence of binocular fixation—is the *position of rest* of the eyes. There is very considerable diversity of opinion, however, as to what should be understood by this position of rest. By many, indeed by most, who have investigated this subject, the latent position for distance is looked upon as the so-called *anatomical position of rest.* This view is certainly incorrect. The ocular muscles, like other muscles in the body, are in a continual state of tonic contraction: they are constantly innervated. The examination referred to can then only reveal the relative position which the eyes take up, independently of binocular fixation, when the muscles are in a com-

paratively passive state—in a state which they assume when, although they are frequently moved to convergence and similarly directed associations, their muscles are only left with that degree of tonic contraction which the repeated response to these impulses entails. It can in fact only be a position of *functional rest.* An examination of a great number of cases of different states of refraction, as to the positions of functional rest of the eyes, shows that:

1. In emmetropia, deviations from parallelism to any consider-

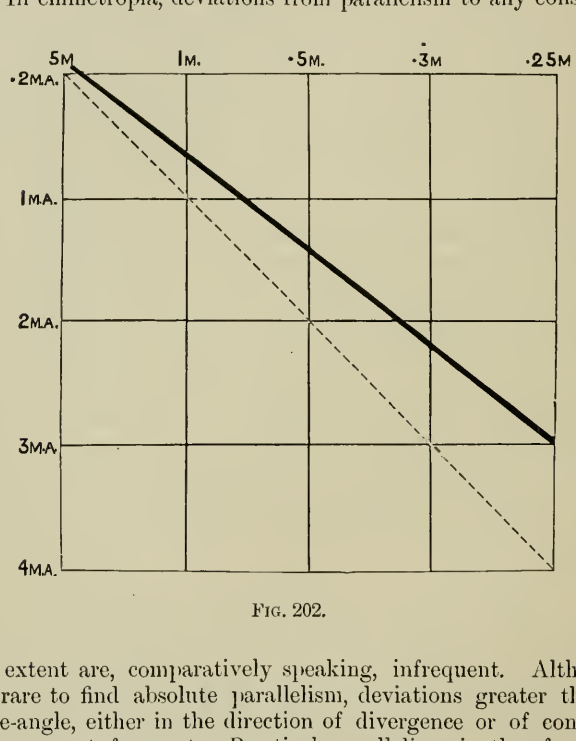


FIG. 202.

able extent are, comparatively speaking, infrequent. Although it is rare to find absolute parallelism, deviations greater than $\frac{1}{5}$ metre-angle, either in the direction of divergence or of convergence, are not frequent. Practical parallelism is therefore the rule. In these deviations from parallelism it is more common to find divergence than convergence. Higher degrees of latent lateral deviation are met with in a small proportion of cases, and more frequently divergence than convergence.

2. In hypermetropia, approximate parallelism is a less common latent position than in emmetropia. Latent convergence is more

common in this state of refraction than latent divergence. The amount, too, of latent convergence in metre-angles is seldom greater than that of the hypermetropia in dioptres.

3. In myopia, approximate parallelism is also less frequent than in emmetropia. Both divergence and convergence are about equally frequent with this condition of refraction, but the degrees of divergence are more often higher than the degrees of convergence. The amount of divergence, too, is only occasionally, and mainly in the very low degrees of myopia, as great (or greater) in metre-angles as the myopia in dioptres.

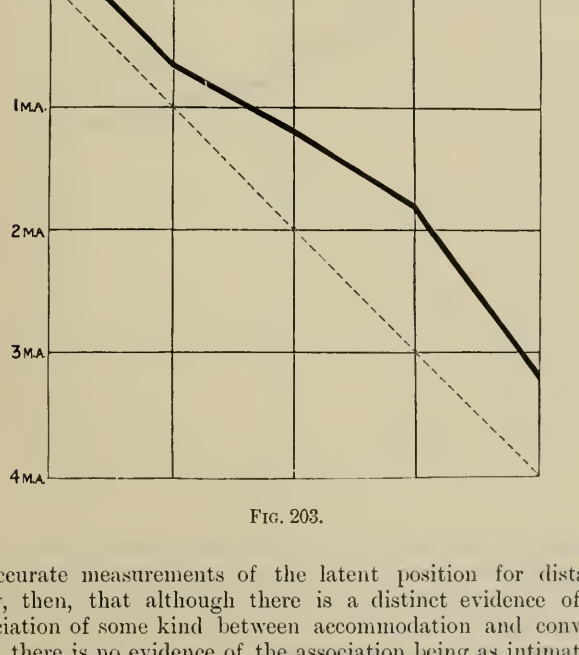


FIG. 203.

Accurate measurements of the latent position for distance show, then, that although there is a distinct evidence of an association of some kind between accommodation and convergence, there is no evidence of the association being as intimate as it might be supposed to be. It does not follow, however, that the actual *impulses* are not associated in a more ideal manner. But if they are, they are for some reason or other prevented from becoming manifested in the actual relations which are found to exist between the extent to which the eyes are accommodated

and converged in the absence, temporarily, of what is of course the supreme controlling influence, namely, the desire for binocular vision, or *fusion* as it is more shortly termed.

We may, besides measuring the latent position for near (say at $\frac{1}{4}$ metre) and for distance, also determine it for intermediate distances. The relation existing throughout may be exhibited in a graphic manner, as shown in the accompanying figures. In these figures the squares are formed by vertical lines, which represent the same distances of fixation from 5 metres to $\frac{1}{4}$ metre,

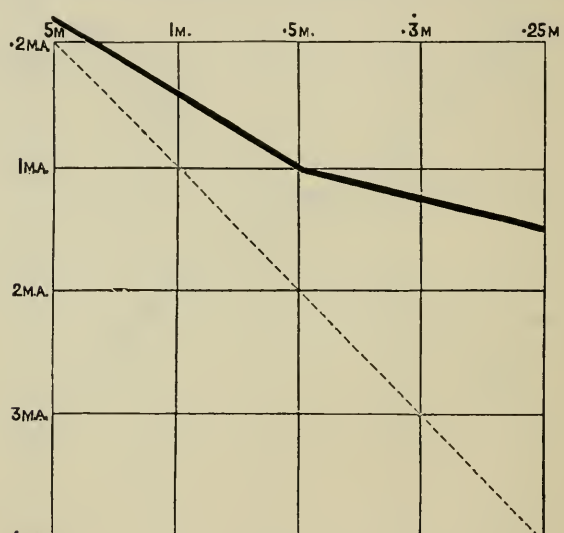


Fig. 204.

crossed by horizontal lines, representing the same degrees of convergence, from 0·2 to 4 metre-angles. The diagonal line is, therefore, in the case of emmetropia, the line of equal accommodation and convergence.

In Fig. 202 is represented the case (a fairly typical one in emmetropia) in which there occurs a gradual lagging of convergence behind accommodation, as nearer and nearer objects are successively fixed. With no, or practically no, accommodation, there is found to be a mere trace of latent divergence; with 2 dioptres of accommodation the divergence has increased to $\frac{1}{2}$ a

metre-angle, whilst 4 dioptres of accommodation, induced by fixation at $\frac{1}{4}$ metre, has advanced it to 1 metre-angle.

The amount of lagging found through the same range in different cases is different. Not infrequently it is barely as much as 1 metre-angle. Sometimes there is less latent divergence on fixation of $\frac{1}{4}$ metre than for $\frac{1}{3}$ metre. Fig. 203 shows this. Sometimes, again, there is considerably more retardation in the convergent movement when unaided by fusion. Such a case is represented by Fig. 204. It is rare that with this relationship there is any discomfort felt in reading.

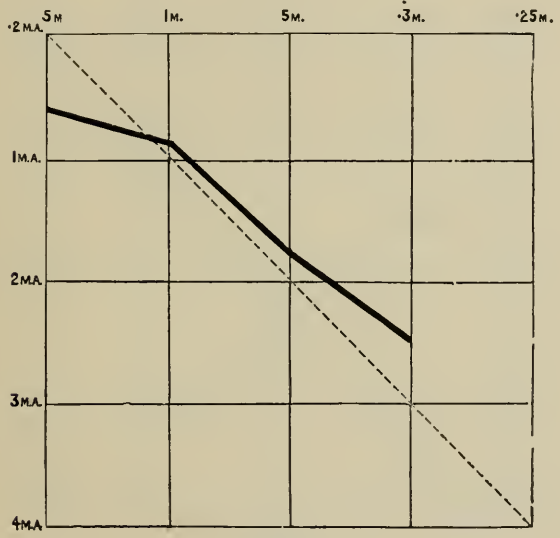


FIG. 205.

A similar high degree of relative latent divergence is found, as a rule, in myopes who are in the habit of reading without correcting glasses.

Even when the latent position for distance is a convergent one, we may see the same lagging of convergence behind accommodation. In Fig. 205 is shown a case in which the latent convergence soon passes, for nearer fixation, to a divergence; while Fig. 206 shows a diminution in the extent of convergence as nearer points are fixed.

When the latent position for distance is a convergent one,

the rule is that there is a greater tendency for the convergence to keep pace with the accommodation, and the more so the more marked the convergence for distance is. In hypermetropia of any considerable degree, for instance, there is little tendency for the latent convergence to diminish as the fixation point is approached to the eye. Fig. 207 shows the retention of convergence in an emmetrope, Fig. 208 the increase of latent convergence for nearer distances in a hypermetrope.

In order to understand better the causes for the apparent difference existing in different cases, in the manner in which

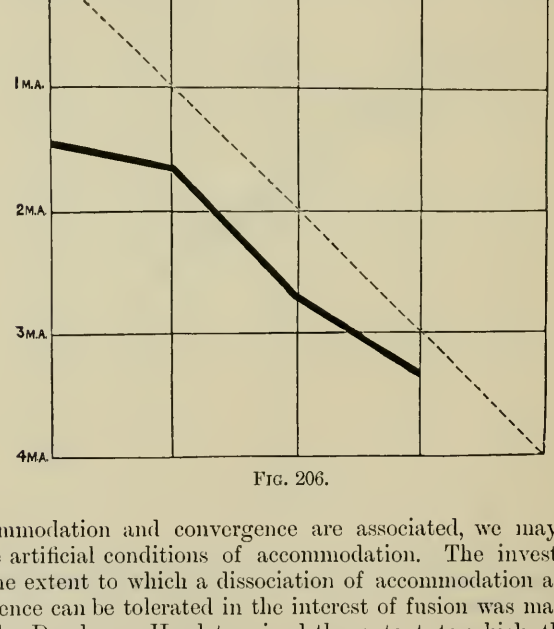


Fig. 206.

accommodation and convergence are associated, we may introduce artificial conditions of accommodation. The investigation of the extent to which a dissociation of accommodation and convergence can be tolerated in the interest of fusion was made long ago by Donders. He determined the extent to which the eyes could overcome by accommodation the effect of concave glasses, while continuing to retain the same degree of convergence, and therefore binocular fixation. Nagel, again, made a series of experiments to test the extent to which adducting prisms could be overcome by convergence without altering the degree of accommodation.

With the object of finding out the change which takes place in convergence in increasing accommodation when binocular vision is temporarily suspended, and an impulse to fusion therefore excluded, we may cause the one eye to overcome concave lenses either on distant or near fixation, and note how, with increasing strength of such lenses, the latent deviation alters in amount. As a rule, if the accommodation be induced in this way, instead of by approaching the object of fixation, it is found that convergence lags still farther behind accommodation. The extent of the difference between the accommodation brought into

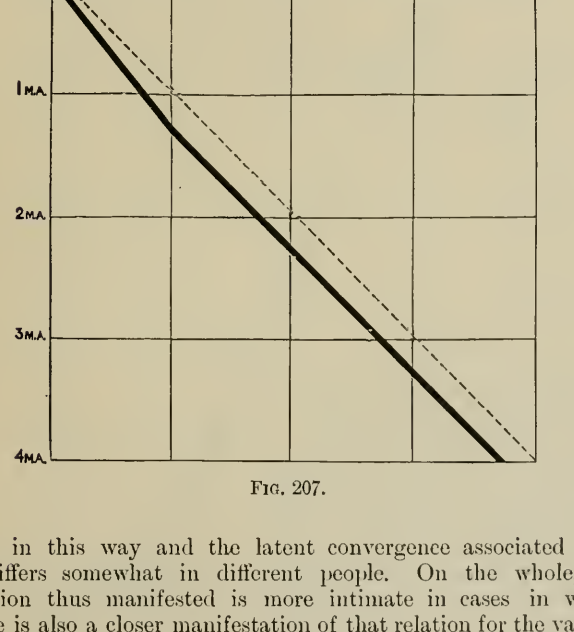


FIG. 207.

play in this way and the latent convergence associated with it differs somewhat in different people. On the whole, the relation thus manifested is more intimate in cases in which there is also a closer manifestation of that relation for the various distances of fixation. The greatest efforts of accommodation, however, are always associated with the closest relations of convergence. Fig. 209 shows the relation manifested between convergence and accommodation in a case in which concave lenses up to 4·0 can be overcome without difficulty. This is an average case. The lagging of convergence is often more, rarely much

less, at all events up to 3 dioptres of accommodation (*i.e.*, an amount which corresponds to what is constantly being used for reading).

Again, a similar test may be made for fixation maintained at a near distance, *e.g.*, $\frac{1}{4}$ metre. If further accommodative effort

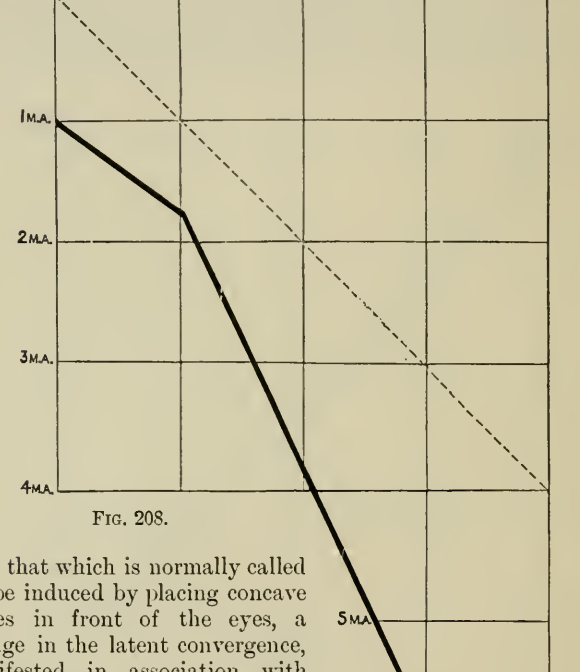


FIG. 208.

than that which is normally called for be induced by placing concave lenses in front of the eyes, a change in the latent convergence, manifested in association with accommodation, is found very similar to that which has just been referred to as taking place for distant fixation. It is interesting, too, to notice the effect of diminishing the accommodative effort by placing convex glasses in front of the eye. Fig. 210 shows the curve of latent convergence where accommodation has been accurately maintained for a distance of $\frac{1}{4}$ metre, under efforts varying from 0 to 8·0 D, by using +4·0, +3·0, +2·0, +1·0, and 0, −1·0, −2·0, −3·0, −4·0 respectively. The total

change through these 8·0 dioptres of accommodation is only 1·7 metre-angle. This shows how very far the degree of manifested convergence, in the temporary absence of binocular vision, is from keeping pace with accommodation.

The same result is got from the examination of the latent position in myopes and hypermetropes, with and without correction, for distant and near fixation. Considerable individual differences are found in this respect, depending partly upon individual peculiarities, and partly upon whether correction is constantly worn or not. On the whole, the difference between the latent

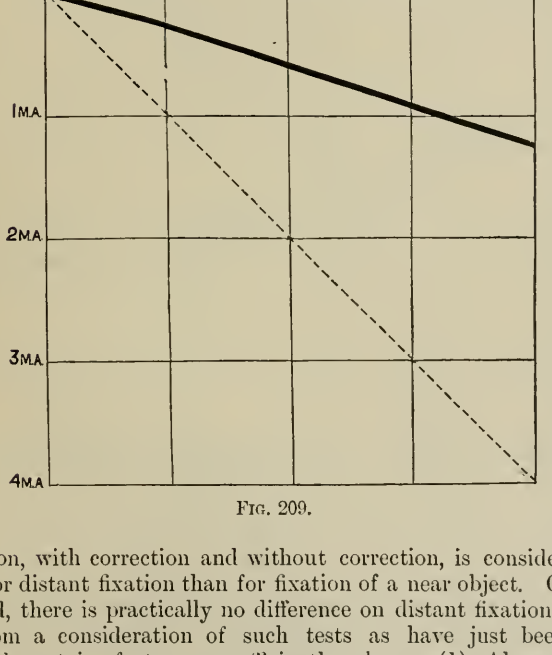


Fig. 209.

position, with correction and without correction, is considerably less for distant fixation than for fixation of a near object. Often, indeed, there is practically no difference on distant fixation.

From a consideration of such tests as have just been described certain facts are sufficiently clear: (1) Along with greater and greater accommodative changes, however induced, some increase in the associated degree of convergence continually takes place; (2) the manifest convergent movements associated with accommodation are usually much less when measured in metre-angles than the accommodation measured in dioptres; and

(3) whenever the conditions necessitate an unusually great effort of accommodation, there is manifested a proportionately large change in the associated degree of convergence.

Whilst then, and whether originally from habit alone or from some closer anatomical connection in the nerve centres, there is clearly an evidence of association between accommodation and convergence, it is doubtful if in cases in which binocular

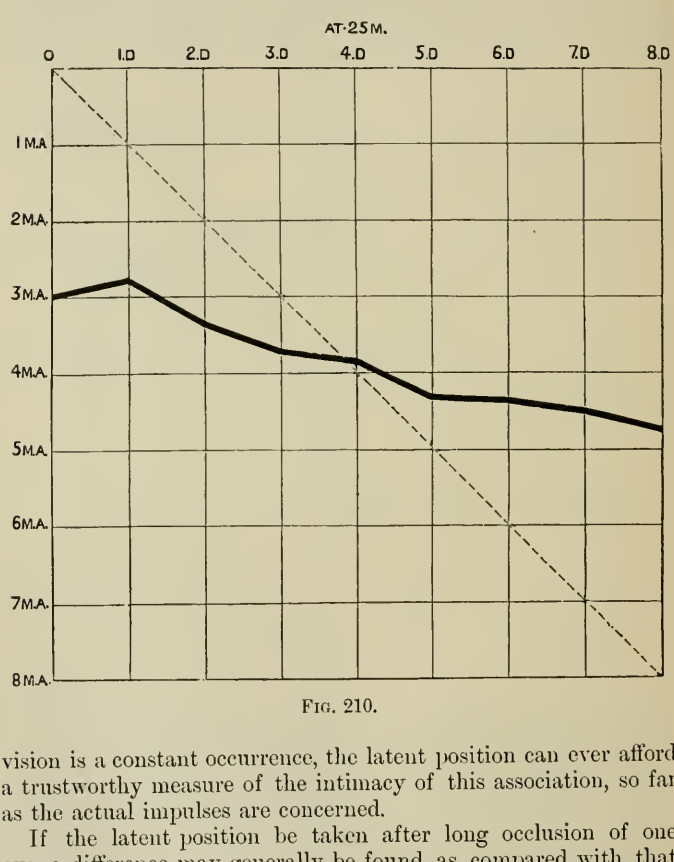


FIG. 210.

vision is a constant occurrence, the latent position can ever afford a trustworthy measure of the intimacy of this association, so far as the actual impulses are concerned.

If the latent position be taken after long occlusion of one eye, a difference may generally be found as compared with that resulting from temporary occlusion. This difference, too, is always indicative of a closer association between the two impulses. Any method of testing based upon prolonged occlusion

of one eye cannot be conveniently applied in many cases. More

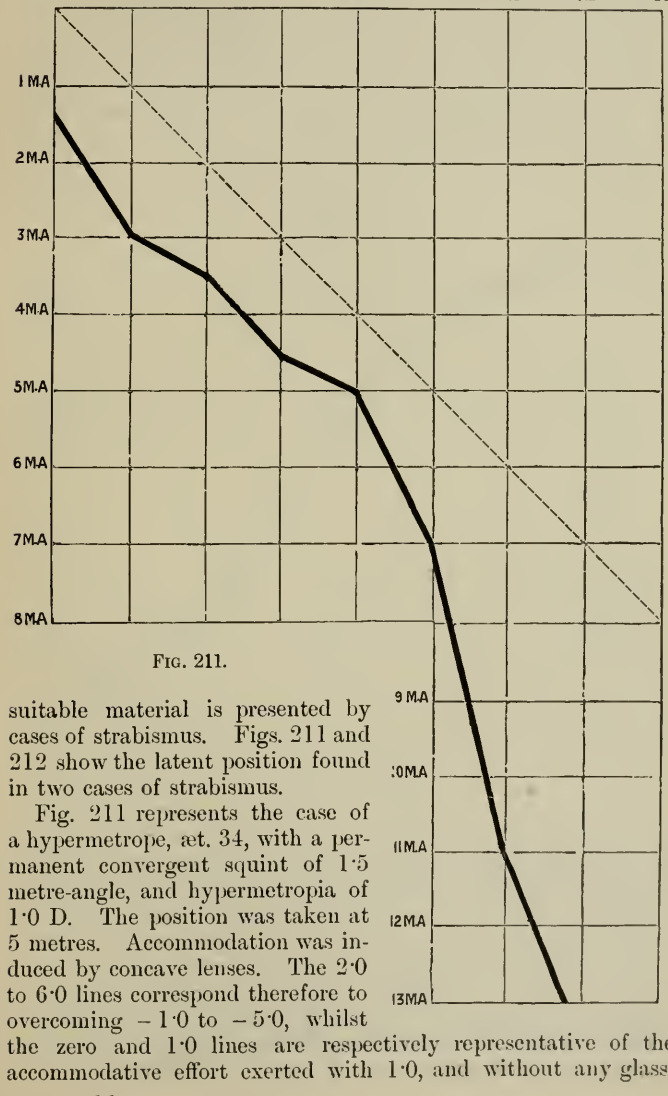


Fig. 211.

suitable material is presented by cases of strabismus. Figs. 211 and 212 show the latent position found in two cases of strabismus.

Fig. 211 represents the case of a hypermetrope, æt. 34, with a permanent convergent squint of 1·5 metre-angle, and hypermetropia of 1·0 D. The position was taken at 5 metres. Accommodation was induced by concave lenses. The 2·0 to 6·0 lines correspond therefore to overcoming $-1{\cdot}0$ to $-5{\cdot}0$, whilst the zero and 1·0 lines are respectively representative of the accommodative effort exerted with 1·0, and without any glass.

The extent to which an association between convergence and accommodation is here manifested is very striking, when compared with such a case as that shown in Fig. 210. The excess of convergence over accommodation, when the limit of accommodative power is approached, is also well marked.

Fig. 212, again, represents the case of a myope of 3·5 D, æt. 10, with periodic divergent strabismus and amblyopia. The latent position was taken for fixation at $\frac{1}{4}$ metre, for which distance only 0·5 of accommodation was necessary. Further

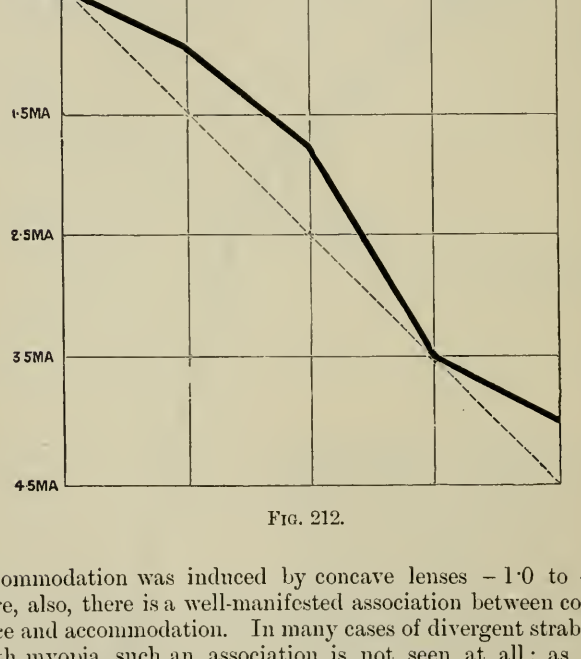


Fig. 212.

accommodation was induced by concave lenses $-1·0$ to $-4·0$; here, also, there is a well-manifested association between convergence and accommodation. In many cases of divergent strabismus, with myopia, such an association is not seen at all; as unless there is binocular vision on near fixation, convergence is gradually altogether unlearned.

The study of the relative directions assumed by the visual axes on the temporary exclusion of binocular vision reveals the fact that fusion has always something, and generally a great deal, to do to correct and counteract the association which exists

between accommodation and convergence. The association is manifested, as we have seen, in quite a different manner where, as in strabismus, binocular vision has been given up. But it is certainly open to doubt whether the connection manifested in such cases indicates the real nature of the association of the two impulses. It is evident, however, that there exists a powerful tendency towards the *persistence* of any particular state of innervation to convergence, which is constantly being called for in the interests of binocular vision. Thus the approximate or complete parallelism of the axes, which is found as the latent position for distance in all states of refraction, must be looked upon as the expression of the persistence of that state of innervation which is so constantly called for by the requirements of binocular vision. The parallelism only exists in cases where associated lateral and convergent movements are constantly being made use of in a normal manner. In the case of near vision, though the same tendency to retain the accustomed position is shown, it is shown, as a rule, to a less extent. The retention is most complete in those who are in the habit of reading, or otherwise using their eyes for near work, unintermittently for hours at a time.

Paralysis of Ocular Muscles.

When the action of any muscle of the eye is weakened, there is a tendency for that eye to lag behind when an attempt is made to turn both eyes in the direction of action of the weakened muscle. In the case of paralysis of either of the lateral recti, the defect in the associated movements of the two eyes to the one side is often quite appreciable on mere inspection, it being evident where the weakness lies, though, if there be only slight paresis, such defect may escape observation. In such cases, and mostly in the case of paresis of other of the oculo-motor muscles, the diagnosis is most readily, or it may be only, arrived at by a consideration of the *diplopia* to which the condition gives rise.

If in any position of fixation the two visual axes do not cross on the object fixed, there is diplopia for that position, provided there existed previously true binocular vision. The diplopia is more and more marked, *i.e.*, the distance of the double images apart is greater and greater, the farther the object fixed lies towards the boundary of action of the weakened muscle.

To facilitate the examination of the nature of the diplopia in any case, it is customary to place a coloured glass—most conveniently a dark red glass—in front of one eye, and cause the patient to look with both eyes at a candle flame held in the ob-

server's hand at a distance of a few feet from the patient. This plan not only renders the diplopia more apparent to the patient, but also indicates to the observer, from the statements elicited from the patient as to the relative positions of the coloured and uncoloured images, that of the eyes themselves. The coloured glass should be held in front of the fixing eye, which is at the same time generally, though not always, the sound one, so far as the muscular defect is concerned. The image in the fixing eye being a foveal one, is always more distinct than the more peripheral image in the deviating eye. Consequently there is produced, when the coloured glass is held in front of the fixing eye, a less considerable difference in the strength of the two impressions than would be the case if it were held in front of the deviating one, and on this account there is less tendency to suppress the image of one eye, which would render the examination of the diplopia impossible.

If one eye is directed straight forward, all objects to the outer side of that fixed by it have their corresponding images on the inner side of the retina, while objects to the nasal side form images on the outer side of the retina. In order to be able to see these objects distinctly, we should have to move the eye outwards or inwards respectively, and to an extent varying with the position of each object. We gradually and unconsciously acquire the knowledge of the relative position of objects from learning, without being aware of it, what amount of innervation is necessary to effect and regulate this directing of the visual axes. We are accordingly in the habit of *projecting* images lying on the nasal side of the centre of the retina away from the middle line, and images lying to the temporal side of the centre of the retina medially. At the same time, and for a similar reason, namely, as the result of the acquired knowledge of the normal position of the eyes, the fields of vision, whatever be their relative position, are, as a rule, mentally superposed, consequently the visual axis of a deviating eye is mentally projected so as to meet that of the fixing eye on the object fixed.

From these two laws it follows that when the position of the deviating eye is one of too great convergence, the image on it of the object fixed by the other eye, falling to the nasal side of the retina, is projected so as to appear displaced, with respect to the image of the fixing eye, in the opposite direction to that of deviation: therefore, in the case of too great convergence of the right eye, to the right, and of the left, to the left. This form of diplopia is called *homonymous*, as the image to the right corresponds to the right eye, and that to the left to

the left eye. Again, if the deviation is one of too great divergence, the eccentric image is for a similar reason projected, as before, in a direction opposite to that of the deviation, which gives rise in this case to what is called *crossed diplopia*, as the image of the right eye appears to the left, and that of the left to the right. Therefore, relatively, too great divergence with respect to the object fixed gives rise to crossed diplopia.

Where there is a paralysis or paresis of any of the muscles which turn the eye outwards, there will be, for certain positions of fixation at anyrate, relatively too great convergence, and consequently, where the other conditions favouring double vision exist, the diplopia will be homonymous. The pareses in which we might therefore expect to find homonymous diplopia are those of the external rectus, and also of either oblique muscle.

Again, when there is paralysis or paresis of any of the muscles which move the eye inwards, there is for certain positions of fixation relatively too great divergence, and consequently the existing double vision is crossed. The pareses in which we find crossed diplopia are therefore those of the internal, superior and inferior recti, muscles.

Besides lateral displacement of the double images, two other directions of displacement require attention, namely, the vertical and the torsional displacements. When one eye lags behind in an attempt at associated vertical movement, or, in other words, when its visual axis deviates from the point fixed, either upwards or downwards, the image on it of the point which is fixed by the fovea of the properly directed eye appears displaced in space in a direction, with respect to the image of the properly directed eye, opposite to that of the deviation—*i.e.*, when the deviation is downwards, the image of the deviating eye appears higher than that of the other; and when the deviation is upwards, the image of the deviating eye is lower than the other. To the lower eye corresponds, then, always the higher image, and *vice versâ*.

The explanation of this is exactly similar to that which has just been given in the case of lateral displacement. The individual is, so to speak, unconscious of the position of the deviating eye, which he imagines to be directed in accordance with the hitherto existing laws of association. He therefore projects its images, not in accordance with their actual positions, but with the positions into which the associated impulse should have brought them, had there been nothing preventing the eye from responding to that impulse.

The same misinterpretation of the actual position of the

deviating eye explains also the torsional displacement of its projected image which is found for definite positions of fixation in some forms of paresis. When, owing to the paralysis or paresis of a muscle, the torsional effect which its action should

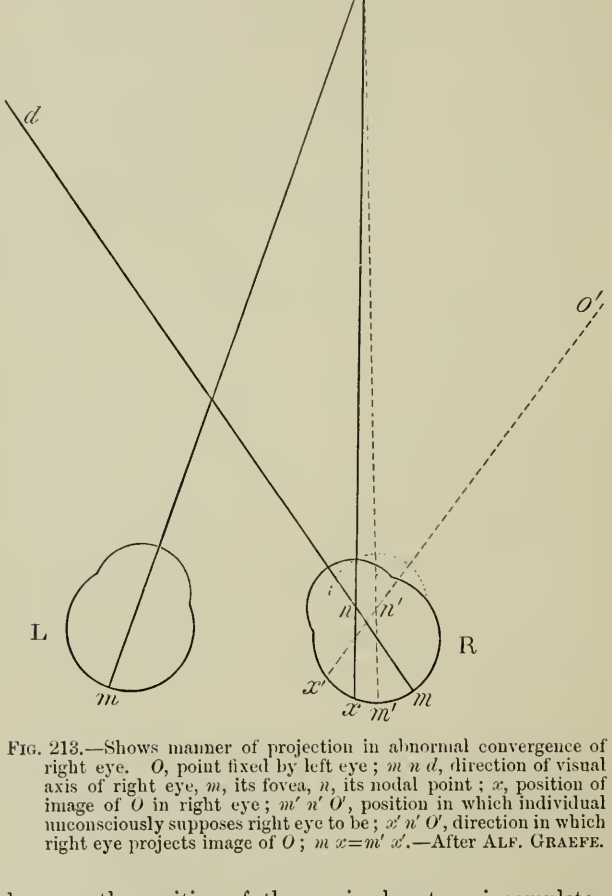


FIG. 213.—Shows manner of projection in abnormal convergence of right eye. *O*, point fixed by left eye; *m n d*, direction of visual axis of right eye, *m*, its fovea, *n*, its nodal point; *x*, position of image of *O* in right eye; *m' n' O'*, position in which individual unconsciously supposes right eye to be; *x' n' O'*, direction in which right eye projects image of *O*; *m x=m' x'*.—After ALF. GRAEFE.

produce on the position of the eye is absent or incomplete, the twisting of the projected image is also in the opposite direction of the deviation: thus if, instead of being twisted to the right, the eye remains untwisted, *i.e.* remains behind the other to

the left, as far as torsion goes, the projected image is sloped to the right.

The manner in which the image of the deviating eye is usually projected explains, too, a symptom which is often met with in fresh cases of paralysis or paresis, namely, a giddiness

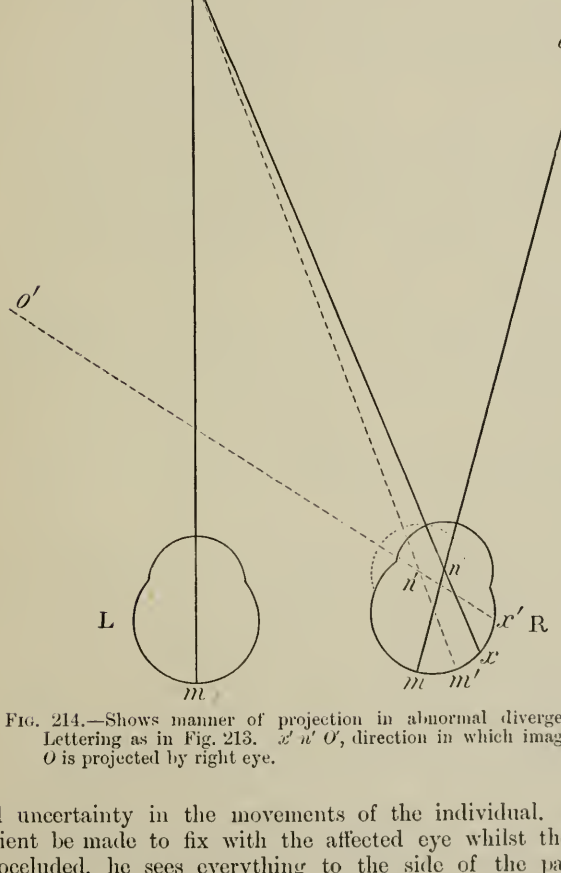


Fig. 214.—Shows manner of projection in abnormal divergence. Lettering as in Fig. 213. x' n' O', direction in which image of O is projected by right eye.

and uncertainty in the movements of the individual. If the patient be made to fix with the affected eye whilst the other is occluded, he sees everything to the side of the paralysed or paretic muscle displaced in the direction of action of that muscle. This may be readily demonstrated by causing him to grasp quickly with the hand of the same side at the object

which he attempts to fix with the affected eye, when it is found that he grasps too far in the direction of action of the weakened muscle. In order that this experiment should succeed properly, his hand must have been previously out of view, and the attempt at grasping be made quickly, otherwise it is evident that the conditions for rectifying the error of projection are introduced. The giddiness disappears when the affected eye is occluded, but not if the sound one is occluded. For a similar reason, it is evident that the difficulties introduced by paresis of the ocular muscles are greater when the affected eye is used for fixation. When this is the case, there is at the same time, when double vision exists, a greater separation of the double images than is the case when the sound eye is the fixing one, because the unwonted effort required by the affected eye for fixation of objects lying in the direction of the action of paretic muscle is associated with a greater movement in the same direction of the other eye, for which there exists no impediment to movement in that direction.

The deviation of the sound eye, when the affected one is used for fixation, is called the *secondary* deviation, as distinguished from the *primary* deviation of the affected eye when the sound one is used for fixation. The secondary deviation is evidently a measure of the degree of abnormal effort required by the weakened muscle to evolve the power required of it. The difference, in the case of paralysis, between the primary and secondary deviations constitutes one of the essential points of distinction between paralytic and ordinary or concomitant squint.

Two circumstances may affect the position of the double images to which paresis of a muscle gives rise—(1) The previous position of equilibrium of the eyes; and (2) the so-called *secondary contracture* of the antagonistic muscle. If the natural position of equilibrium be one of considerable divergence, the homonymous displacement of the double images in paralysis of an oblique muscle may not appear; if it be one of considerable convergence, on the other hand, the crossed character of the lateral displacement in paralysis of the superior or inferior rectus may not be present. When, again, there is a so-called secondary contracture of an antagonistic muscle, the area over which the diplopia becomes manifest in any case is extended, so that instead of merely existing in the direction of action of the weakened muscle, it extends over more or less of that of the antagonist as well. The occurrence of a secondary contracture is not altogether dependent on the degree of the primary defect.

When the secondary contracture is marked, there is not so frequently diplopia.

Secondary contracture in ocular paralysis is not analogous to contracture of muscles elsewhere in the body. There is, for instance, no fixing of the eye in one position ; it is free to move in the direction opposite to that of the supposed contraction. The term is obviously a misnomer. The cause of the preponderating action of the one muscle in any case is, in fact, the alteration produced in the relative innervation of the antagonistic muscles, owing to the loss, gradual or sudden, of the tonic innervation of the paralysed or paretic muscle.

It is not always easy to tell, without determining the nature of the diplopia, for which eye the paresis exists. This is, however, readily done by noting *to which eye that image belongs which lies farthest in the direction in which fixation is attempted.* That eye, therefore, lags behind, and does so owing to a weakness of the muscle which should move it in that direction.

The image which appears in the wrong place is often recognised by the patient himself as the *false* image, that which is seen in its proper place as the *true.* As the sound eye is generally used for fixation, the false image is at the same time most frequently less distinct than the true one, corresponding as it does to a peripheral retinal impression.

There may be paralysis or paresis of one or more ocular muscles without any diplopia. There are several reasons for this. When a deviation of the axis exists for some definite positions, and yet does not give rise to the diplopia which should characterise the strabismus, this is either because the image of the deviating eye is suppressed, or because the patient has acquired the habit of projecting the images falling on the deviating eye in accordance with the position it assumes, and not in accordance, as is the rule, with the impulse to associated movements.

The first is the more common cause. But even when there is in no position any deviation, there may yet exist a paretic condition of one of the ocular muscles. Thus it often happens that the paresis is so slight that it can be overcome by fusion in the interest of binocular vision. This is, of course, most common in cases of paresis of one of the lateral muscles, as the power of fusion is greatest laterally. In order to detect whether there is a hidden paresis of this nature, all that is necessary in the case of the lateral muscles is to place a prism, with the base directed exactly upwards or downwards, in front of one eye, and note whether there is (1) any lateral displacement of the resulting

double image in addition to the vertical displacement produced by the prism; and (2) whether the lateral displacement increases to one side and diminishes to the other. A lateral displacement which did not alter in extent to either side would, of course, not indicate a paresis of any particular muscle, but merely the position assumed by the eyes for fixation at the distance at which the test was made when deprived of the regulating influence of fusion.

Relative frequency of different ocular paralysis.—Of the three nerves which supply the muscles of the eye, the third and sixth are more frequently paralysed than the fourth. If we consider the relative frequency of the occurrence of paralysis or paresis of isolated muscles, we find that that of the external rectus is the most frequent. Next in order, and about half as frequent, is an isolated paresis of the superior oblique. Then come the paresis of either the superior or inferior rectus alone, though these are much less frequent; and, lastly, the isolated paresis of the internus and of the inferior oblique, the latter of which is of very rare occurrence.

Simultaneous paralysis of several muscles of one or both eyes.—Besides the isolated paralysis of the nerves which supply the muscles of the eye, or of the twigs supplying special muscles, we meet with all possible varieties of more complicated paralysis in one or both eyes, the diagnosis of which can be generally readily enough made from a consideration of the double images. The most common combination is a simultaneous weakness of several or all of the muscles supplied by the third nerve. An interesting form of complicated paralysis is the *paralysis of associated movements.* It is characteristic of these cases of paralysis, when they occur in an uncomplicated form, that there is, with one exception (*vide infra*), an entire absence of diplopia. The reason of this is that the restriction exists to exactly the same extent in both eyes.

The forms in which I have met with associated paralysis are :—

1. Paralysis or paresis of both eyes to the right, or of both eyes to the left.

2. Paralysis of movement of both eyes to either side.

In all the cases coming under these two headings there has been retention of the power of convergence, and an absence of diplopia.

3. Paralysis or paresis of movement of both eyes upwards, without diplopia.

4. Paralysis or paresis of movement of both eyes downwards, without diplopia.

5. Paralysis of both upward and downward movements, with retention of lateral movements and convergence.

6. Paralysis or paresis of convergence, with crossed diplopia for near objects.

The last is by far the most common. Next in order of frequency, in my experience, comes the first, namely, acquired defective movement to one or other side. This is always due to a lesion of the sixth nerve nucleus of the same side. The most infrequent are the cases in which associated movements in more than one direction are restricted paralytically.

Occasionally there is paralysis of the same muscle or muscles on both sides. I have most frequently seen paralysis of both externi, but I have also met with paralysis of both interni, and of the two inferior recti alone. Paralysis of both externi is often very incomplete—only a slight paresis. The diagnosis is easily made by observing a marked increase in the separation of the homonymous double images on fixation to either side. Paralysis of the inferior recti is diagnosed, from paralysis of associated movement downwards, by the existence of diplopia in the secondary positions. Paralysis of all the external muscles of both eyes occurs either as one of the manifestations of gross cerebral disease or owing to disease of the nuclei of third, fourth, and sixth nerves—sometimes the two third nerves alone are paralysed.

Paralysis of the external rectus, or sixth nerve.—When this condition exists, the power of abduction is more or less completely lost. If there has previously been binocular vision, and the paralysis is recent, there is homonymous diplopia, which almost invariably extends more or less over to the side of the sound eye. The double images increase in distance apart, the farther the object is carried to the side of the affected eye. For equal lateral distances from the middle line, the double images are generally farther apart for fixation below the horizontal plane through the eyes than for fixation above that plane. The reason of this is that divergence in the interest of fusion with the eyes lowered is more difficult, because rarely required, than with the eyes raised. At the same time the false image in the secondary positions is often slightly inclined from the true one above, and towards it below. This arises from the absence of torsion, caused by the want of participation of the outward movement with the vertical movements of the eye.

Fig. 215 gives schematically the positions of the double images. Paralysis of the right external rectus is more distressing than paralysis of the left, owing to its interfering more with reading.

Frequently the patient keeps his head rotated to the side of the paralysed muscle, and fixes objects straight in front of him with his eyes turned to the other side. In this way he effects a more useful disposal of the area of single vision. The lesion producing paralysis of the sixth may be central or peripheral, and the causes various.

Paralysis of the superior oblique muscle, or fourth nerve. —In this paralysis there is more or less restriction in the power of moving the eye downwards, most marked when the eye is directed inwards. The diplopia exists only in the lower half of the field of fixation, unless the preponderance of the inferior

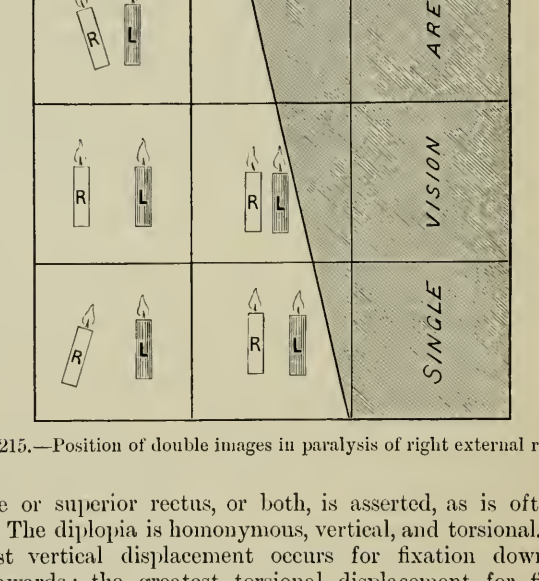


Fig. 215.—Position of double images in paralysis of right external rectus.

oblique or superior rectus, or both, is asserted, as is often the case. The diplopia is homonymous, vertical, and torsional. The greatest vertical displacement occurs for fixation downwards and inwards; the greatest torsional displacement, for fixation downwards and outwards; the images slope towards each other. Sometimes the homonymous character of the diplopia is not marked, or the images may even be crossed and sloping from each other. This is owing to the coexistence of a latent divergence.

Fig. 216 gives schematically the arrangement of the double images in the primary and secondary positions. (Compare with

chart for inferior rectus.) Paralysis of the superior oblique causes difficulty in moving about, especially in going down stairs. The patient generally holds his head downwards, and towards the sound eye, and thus effects a more useful disposal of the area of single vision. The lesion in paralysis of the fourth nerve is either peripheral or central, and the causes various.

Paralysis of the inferior rectus.—Movement of the eye downwards is more or less restricted, mostly when turned outwards. The diplopia exists only for the lower part of the field of fixation, except when there is a manifest preponderance of

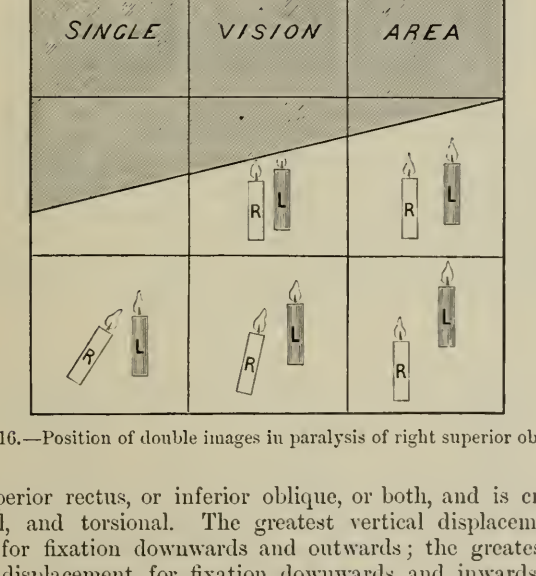


FIG. 216.—Position of double images in paralysis of right superior oblique.

the superior rectus, or inferior oblique, or both, and is crossed, vertical, and torsional. The greatest vertical displacement is found for fixation downwards and outwards; the greatest torsional displacement, for fixation downwards and inwards; and the double images slope towards each other. Occasionally the diplopia, instead of being crossed, is homonymous, and the images slope away from each other. This is owing to the coexistence there of a latent convergence. Fig. 217 gives schematically the relative positions of the double images in the lower part of the field of fixation. (Compare with those of superior oblique.) The inferior rectus is seldom paralysed alone,

though frequently along with other muscles supplied by the third nerve.

Paralysis of the superior rectus.—Movements of the eye upwards are more or less restricted, principally when it is turned outwards. Attempts to move the eye upwards are associated often with retraction of the upper lid, giving a staring appear-

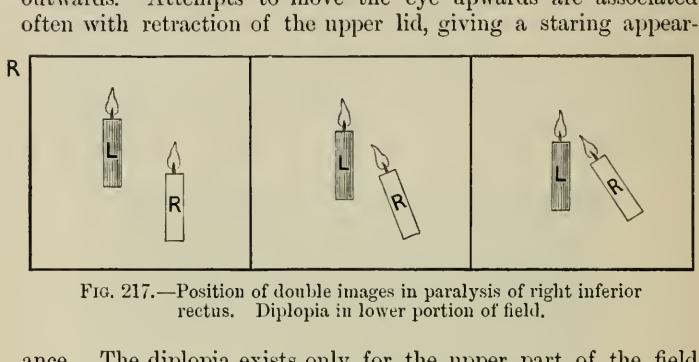


Fig. 217.—Position of double images in paralysis of right inferior rectus. Diplopia in lower portion of field.

ance. The diplopia exists only for the upper part of the field of fixation, except when there is a manifest preponderance of the inferior rectus, or superior oblique, or both, and is crossed, vertical, and torsional. The greatest vertical separation of the images occurs for fixation upwards and outwards; the greatest torsional displacement, for fixation upwards and inwards; and the images slope away from each other. When the eye is displaced

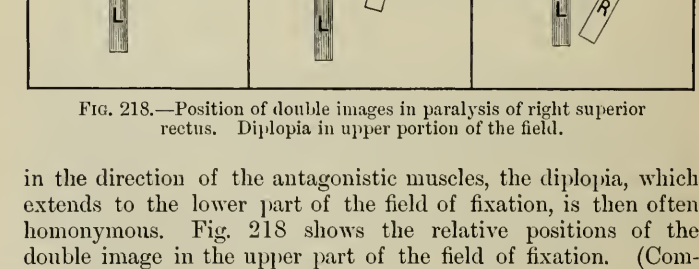


Fig. 218.—Position of double images in paralysis of right superior rectus. Diplopia in upper portion of the field.

in the direction of the antagonistic muscles, the diplopia, which extends to the lower part of the field of fixation, is then often homonymous. Fig. 218 shows the relative positions of the double image in the upper part of the field of fixation. (Compare with diagram for paralysis of inferior oblique.) The superior rectus is seldom paralysed alone, though often along with other muscles supplied by the third nerve.

Paralysis of the inferior oblique.—Movements of the eye upwards are restricted, especially when it is at the same time adducted. Diplopia, unless there is a manifest preponderance of one of the muscles which rotate the eye downwards, only exists for the upper portion of the field of fixation, and is homonymous, vertical, and torsional. The greatest difference in height of the double images is seen for attempts at fixation upwards and inwards, the greatest torsion for fixation upwards and outwards, and the images slope away from each other. Fig. 219 shows the position of the double images in the upper portion of the field of fixation. (Compare with those caused by paralysis of superior rectus.)

The inferior oblique is almost never paralysed alone, though often along with other muscles supplied by the third nerve. Occasionally a paralysis of this muscle has been met with owing to the accidental detachment of its origin, caused by wounds

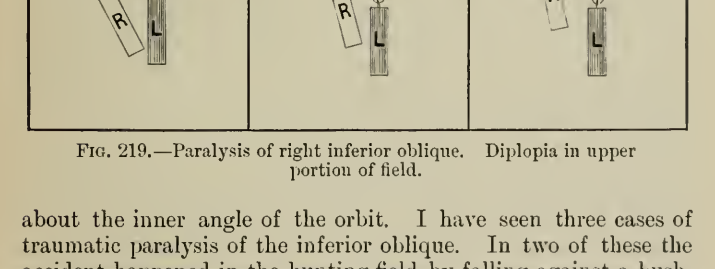


Fig. 219.—Paralysis of right inferior oblique. Diplopia in upper portion of field.

about the inner angle of the orbit. I have seen three cases of traumatic paralysis of the inferior oblique. In two of these the accident happened in the hunting-field by falling against a bush, a twig of which caused laceration of the muscle origin. The third occurred to a medical man, who, in a fall from a bicycle, wounded the lower orbital margin by striking against the handle of the machine.

Paralysis of the internal rectus.—There is more or less restriction of the inward movement of the eye. Diplopia, owing to manifest preponderance of the externus, stretches more or less over to the side of the field opposite to that of the affected eye. The diplopia is crossed, and the double images increase in distance apart as the object fixed is carried to the side of the affected eye. In the secondary positions there is slight sloping of the false image as well. Paralysis of the internal rectus is one of the rarest forms of isolated paralysis, though it is often

the muscle most completely weakened when the third nerve as a whole is paralysed.

Paralysis of the third nerve.—There is more or less drooping of the upper lid, mydriasis, and defective accommodation. Movements of the eye inwards, upwards, and downwards are more or less completely abolished. The amount of possible downward movement is not only dependent on the degree of paralysis of inferior rectus, but also on that of the internus as well. The more imperfect the adduction, the less does the action of the superior oblique in turning the eye downwards come into play. Diplopia exists all over the field of fixation, the false image lies below the true, and is sloped outwards both for fixation outwards and inwards. Paralysis of the third nerve is very common, and is often incomplete, occasionally one, though more frequently two or more, of the muscles being alone affected, or more markedly affected, than the others. The lesion may be central or peripheral, and the causes various. When there is complete paralysis of the internus, it is not always quite easy to be sure of the action of the superior oblique. Inward rotation, which should theoretically take place on attempting to move the eye downwards, is often conspicuously absent. It must not be inferred from this that the fourth nerve is also paralysed, as, owing to loss of tonic contraction in the upward rotators which are involved in the paralysis, the preponderance of the superior oblique has already led to torsion.

If, however, there should be any appreciable torsion of the eye inwards when the attempt is made to look down, we may be pretty sure that the fourth nerve is not paralysed.

The lesions giving rise to oculo-motor paralysis may be peripheral or central. Peripheral lesions are such as involve the nerve trunks or their branches, either in the intra-cranial or in the orbital portions of their course. Other orbital peripheral causes of paralysis may be lesions which directly impair the functional activity of the muscles themselves. Many congenital paralyses depend upon muscle defects. Orbital cellulitis and periostitis and tumours may affect either the nerves or the muscles, or both, and thus cause paralysis. The intra-cranial peripheral or basal lesions leading to paralysis are various. They may be traumata, as in rupture of the nerve trunks in fracture of the base of the skull. They may be inflammatory, of rheumatic, syphilitic, tuberculous, or other origin, and then be occasionally subject to recurrence. In many cases they are caused by pressure: from tumours, fibrous bands, blood clots, aneurysms, œdematous brain tissue, etc.

Central lesions, on the other hand, are those which involve either the nuclei of the oculo-motor nerves or the various fibres which, passing from the nuclei, are collected to form the different nerve trunks. Nuclear paralyses may be due to primary pathological changes in the cells, and these changes may be of various natures. They may be, for instance, degenerations of more or less obscure origin, sometimes inflammatory; or caused by circumscribed sclerosis, which are then, however, usually mere localised patches, connected with a more widespread process of the same nature, as in tabes. Circulatory disturbances, hæmorrhagic and other, may be limited to the region of the oculo-motor nuclei. Various poisons, too, both ecto- and ento-genetic, may disturb more or less completely and permanently the vitality of the cells in this situation. Alcohol,—possibly also tobacco,—diphtheria, and diabetes are causes of this nature. Then, again, there may be direct pressure on the nuclei, or the fibres which pass from them, by tumours of the pons, intra-ventricular hæmorrhages, or cerebral œdema. Nuclear lesions are usually the cause of the different varieties of *associated* ocular paralysis in which muscles which act together in the two eyes are deprived of their impulses to associated contraction.

It is by no means generally easy to arrive at a correct diagnosis of the site of the lesion causing an oculo-motor paralysis. The points to be considered in attempting to do so are—(1) The manner in which the paralysis is distributed over the nerves of one or both eyes; (2) the completeness of the paralysis itself; (3) the existence and nature of complications, such as optic neuritis, paralysis of the facial, sympathetic, and fifth nerves. In many cases of severe intra-cranial disease the ocular paralyses may be of secondary importance to the other symptoms.

In some cases, and particularly in the case of orbital lesions, there may be little difficulty. One eye alone is then affected, and the restriction in its power of movement may be associated with exophthalmos, or with optic neuritis on that side only.

An intra-cranial peripheral causation may usually be inferred when all the muscles supplied by the third nerve, both intra- and extra-ocular, are affected, or when several muscles of both eyes, which are not associated muscles, are paretic, or, in the case of the implication of associated muscles alone, if the degree of the defect differs markedly in the two eyes. The existence at the same time of a double optic neuritis would, as a rule, justify the diagnosis, especially in the absence of febrile symptoms, of tumour pressing on the nerve trunks.

A nuclear causation would be indicated when, for instance, there was any definite associated defect of movement in the two eyes in some particular direction, or when in one or both eyes some or all of the external muscle branches of the third nerve were found to be paretic without any impairment in the activity of the ciliary and sphincter pupillæ muscles.

Both as regards the prognosis of recovery from the local paresis and the chance of extension of the lesion to more vital parts, peripheral causations are to be looked upon as less serious, in general, than nuclear ones. The main exceptions to this are cases of basal paralyses caused by tumour pressure,—in which, of course, the prognosis, though the nerve lesion is a peripheral one, is bad,—and the cases of toxic nuclear paralyses, especially post-diphtheritic, in which the prognosis is generally favourable.

Occasionally we meet with congenital paralysis, the most common being ptosis and paralysis of one or both sixth nerves. Many of these cases are no doubt due to congenital muscular defects, and are not true paralyses at all. Our knowledge on this subject is, so far, very defective.

The *treatment* of ocular paralysis should be general and local. When the primary cause of the paralysis—be it rheumatism, syphilis, or changes in the nervous system, or due to diphtheria or any other form of poisoning—is apparent, or when there exist sufficient grounds for suspecting any definite cause, the treatment found to be most efficacious in the particular affection should be at once adopted.

Local treatment may be instituted on three lines—(1) Passive movements of the eye in the direction of the action of the weakened muscle; (2) attempts to induce active movements of the weakened muscle; (3) operations calculated to bring about a more advantageous relative position of the paralysed muscle and its antagonist.

Passive movements of the eye are made by seizing the conjunctiva with the fixation forceps and rotating the eye forcibly several times in succession, and once or twice daily, in the direction of the action of the weakened muscle. This can be done without causing any pain, by the use of cocaine.

Attempts to induce active movement of the weakened muscle may be made in many ways. The simplest method is to cause the patient to fix binocularly some definite object, such as a printed word, and to carry this object gradually farther and farther in the direction of the area of double vision, whilst he is all the time making an effort to fuse the images of the two eyes, which tend more and more to separate. The tendency to fusion

is sometimes so strong in cases where the internal rectus is paretic, that the strain which maintaining binocular vision entails is not only the cause of considerable discomfort, and even pain, but may not improbably tend to retard the complete recovery. In such cases the patient may obtain great relief by the use of prisms of 3° or 4°, with their bases inwards in front of each eye. By this treatment the efforts of fusion are supported and the strain lessened.

Electrical stimulation of the weakened muscle, either by the constant or induced current, is recommended by many, and is occasionally of use. One pole is brought in contact with the forehead, and the other with the closed lid over the affected muscle.

There is a great tendency for the paralysis of ocular muscles to disappear more or less suddenly, and after having existed for a longer or shorter period. Some cases, indeed, only last a few days. Operative interference should not be thought of until the condition has remained unaltered for a sufficiently long period to render impossible any improvement by other means. Treatment by operation is only suitable in a small proportion of cases of paralysis of oculo-motor muscles. Interference of this nature should in the first place be deferred until a full year has passed since the onset of the paralysis. The advisability of operating will then depend upon whether the affection of innervation of the ocular muscle is the main or only symptom present, or whether it constitutes merely one symptom among many others indicative of serious cerebral disease. In the latter case nothing should be done; in the former, if one muscle alone is weakened, or if the paresis is only marked in the case of one muscle, it is sometimes possible to improve matters more or less considerably.

As isolated paralyses of the muscles supplied by the third nerve are of comparatively rare occurrence, it follows that the cases which most frequently offer a chance of improvement by operation are persistent cases of paralytic weakening of the external rectus and of the superior oblique. Cases of paresis of the external rectus of one eye are not only amongst the most frequent, but fortunately at the same time those for which most can be done by operation. In such cases the operative effect can be regulated with greater nicety, as, just as for concomitant convergent strabismus, the improvement in the relative position of the eyes can be produced by the combination of tenotomy of one or both internal recti with the advancement of one or both external recti, according to the degree of the defect to be rectified, while there is besides a greater natural tendency, as has

already been explained, to the fusion of the double images, which frequently heightens the effect of a suitable operation.

The cases for which operations may be performed present considerable differences with respect to the completeness of the remaining paralysis, as well as the degree of manifest preponderance in the action of the internal rectus or antagonist muscle; the extent of the tendency to fusion must also be taken into consideration in the selection of what operation or operations should be performed in any given case. The main object of any operation is to displace the area over which double vision exists as much as possible to the side of action of the paralysed muscle. In all cases, therefore, in which some power has been retained by, or restored to, the external rectus, it will generally be possible to effect this, to an extent which is practically sufficient, by correcting the degree of convergent squint which exists for the fixation of objects in the middle line; while the improvement thus obtained will be more complete the greater is the degree of such remaining power and the greater the desire for fusion.

Cases of persistent paresis of the superior oblique do not lend themselves to such complete readjustment, as it is impossible either properly to advance the paretic muscle or to weaken the mechanism of rotation which is antagonistic to that produced by the superior oblique, as that could only be effected by tenotomy of both the inferior rectus and the inferior oblique, the latter of which cannot be satisfactorily done. Nevertheless, by tenotomy of the inferior rectus of the other eye a very considerable favourable displacement of the area of diplopia can be obtained in suitable cases.

Spasms of Ocular Muscles.

Spasmodic contractions of single oculo-motor muscles are not only of extremely rare occurrence, but owing to their inconstancy they are very difficult to diagnose. A much more common occurrence is a spasm of associated movement. In consequence of cerebral irritation, to account for which there may or may not be some definite lesion, a forcible deviation of the eyes takes place in some particular direction—to either side, or upwards or downwards, or it may be a spasm of the convergent movement of the two eyes. Spasm of convergence is not altogether rare. I have seen many cases. The condition is characterised by homonymous diplopia, with a diminution in the separation of the double images on fixation to either side.

As a rule it does not last many weeks, and is besides subject to variation in degree from day to day. The approximation of the double images to either side shows that the same degree of convergence is not maintained as the eyes move in association laterally. The effect of an irritation of the converging centre appears, in fact, to be to withdraw the relaxation of convergence beyond a definite point (the position of which is subject to variation) from the control of the will, and yet to leave the play of convergence, as the eyes move from side to side, to be effected in a habitual manner. It is similar, in fact, to the convergent movements which would take place if, on attempting to fix a more distant object moved from side to side, the eyes kept converged on points in a plane which lay nearer to them.

At other times one meets, and mostly in cases of severe cerebral disease, with what has been called a disjunction of the co-ordinated movements of the eyes, in which the movements of the eyes appear to be greatly or entirely independent of each other, and to be at the same time deprived of volitional control.

No general lines can be laid down for the treatment of such cases of associated or dissociated involuntary movements. Each case has to be considered for itself, but the important point to remember is that they are by no means invariably indicative of serious cerebral disorder.

Concomitant Strabismus.

In the normal state of the eyes, when any object is looked at, the visual axes of both eyes are directed simultaneously on the same point of the object. There is therefore simultaneous *fixation* with both eyes. When only one eye is directed towards, or fixes, the object engaging attention, while the line of vision of the other crosses that of the fixing eye, either in front of or behind, or above or below it, there is said to be squinting, or strabismus. In the scientific acceptation of the term there can only be strabismus of one eye at a time, as it is clear that one eye must always, when it is possible at all, be directed on the object looked at.

Bilateral deviations and conditions of vision which render this impossible do not come under the category of strabismus.

According to the direction assumed by the axis of the deviating eye, we have to distinguish between strabismus *convergens* and *divergens* and strabismus *sursum vergens* and *deorsum vergens*. The vertical deviations, upwards and downwards, though often combined with lateral deviations, are rare alone,

and are consequently of less practical importance. They frequently remain after the lateral deviations have been corrected by operation. Convergent and divergent squints are common.

When there is for no distance of fixation, either near or remote, a coincidence of the axes of vision, the strabismus is said to be *absolute*. When both eyes are properly directed on fixing a near object, but one axis misdirected when a distant object is looked at, or when the misdirection of one axis takes place only on fixation of a near, but not of a distant, object, the strabismus is said to be *relative*.

The strabismus may be *constant* or *intermittent*. It may always be confined to the one eye,—*i.e.*, it may be *unilateral*,—or it may be *alternating*, when objects to the one side are fixed by the one eye and to the other side by the other eye. It may or may not be associated with diplopia.

As we have already seen, besides *manifest* strabismus, similar deviations are found to occur when one eye is occluded. There is then said to be a *latent* strabismus. The consideration of latent forms of strabismus is of importance, as they may under certain circumstances become manifest, or they may—though by no means so frequently as was at one time supposed—give rise to pain or discomfort: to that form of asthenopia which is called *muscular asthenopia* (see p. 556).

Mere inspection is not always sufficient to enable us to diagnose a squint, as on the one hand there may be a slight deviation without its being apparent, and on the other hand there may appear to be a deviation when in reality both eyes are properly directed. This may occur either when the eyes are not fixing the object which it is supposed they are fixing, or when the angle between the optic and visual axes is considerably larger or smaller than usual. Thus in hypermetropia an apparent divergence is due to an abnormal size of this angle; whilst in some myopes a negative value of the same angle gives rise to an apparent convergence, which is sometimes extremely marked.

It is necessary, therefore, in some cases at anyrate, to adopt the following method of testing whether there is or is not any squint. The patient is made to fix some distant object; whilst he is doing so, the observer covers one eye, and notices whether the one which remains uncovered makes any movement in any direction. The patient is then again made to fix the same object, and his other eye is in the same manner occluded by the observer's hand, and any movement of the uncovered eye looked for. A similar test is then made for the fixation of a near

object—at 10″ from the eye. If the one eye has been misdirected while both were open, and if it at the same time is in possession of sufficient visual acuity for central fixation, it will take up the fixation of the object looked at as soon as the fixing eye is occluded from vision. In order to do so it will have to make a movement in a direction exactly opposite to that in which it previously deviated; so that a movement outwards of the other eye, on occlusion of the fixing one, is a proof of the existence of manifest convergent strabismus; a movement inwards, of manifest divergent strabismus. If the movements just described take place both for fixation of near and distant objects, the manifest strabismus is diagnosed as absolute; if only for one or other, as relative.

Care must be taken that the occluding hand is not transferred too quickly from the one eye to the other, which would cause a difficulty in distinguishing which was the squinting eye. Time must be allowed for the fixation to take place in the way in which it is ordinarily effected. If the conditions of fixation be the same for both eyes, the squint is almost invariably transferred from the one eye to the other—*i.e.*, the occluded eye, whether it be the one usually employed in fixation or not, is misdirected. This can generally easily be seen by observing the position which it assumes behind the occluding hand. The fact is, that although the defect is one rendering the position of the two eyes either too convergent or too divergent relatively to the distance of the object looked at, it necessarily only becomes apparent on the one, as the other has to maintain a proper direction of fixation.

A truly alternating squint presents the following characteristics. If either eye, by first covering the other with the hand, be caused to fix an object in the middle line, *i.e.* straight out from the nose, it subsequently remains for an indefinite period, after removing the occluding hand, in the position of fixation. It is evident that it is immaterial to the individual which eye he makes use of for fixation in this position. Again, on moving the object of fixation to the right, it is fixed by the left eye, whilst the right eye fixes it when situated to the left of the middle line. Both eyes have equal, or very nearly equal, vision, and are often emmetropic.

The ordinary squint differs from the paralytic squint in this respect, that whereas in the latter the extent of the deviation increases in certain directions, it remains in the former the same for all directions. For this reason it is called *concomitant*. The degree of concomitance, too, as measured by accurate tests, is

found to be very complete. In concomitant, as well as paralytic squint, there is often less convergence when the eyes are directed upwards, and more when they are directed downwards, than when fixation takes place for objects in the horizontal plane through the eyes.

The ordinary laws of the transference of the squint from the one eye to the other when the fixing eye is occluded, and the equality of the primary and secondary angles by which a concomitant squint differs from a paralytic squint, are not altogether without exceptions. When, for instance, there is a difference of refraction in the two eyes, the accommodation required when one eye fixes is different from that which is required by the other for the same distance, and consequently the same association between accommodation and convergence leads to a difference in the relative directions of the two axes of vision, according as one or the other fixes. A very common instance of this is the case where one eye is myopic, while the other is emmetropic. The emmetropic eye is used for distant fixation, and there is then, it may be, no squint. For near vision it is frequently, on the other hand, the myopic eye which is used, while the other diverges. If, however, the myopic eye be occluded, and the emmetropic one used for fixation, the *secondary* deviation (behind the occluding hand) is either considerably less or absent altogether. Often there is found to be in such cases divergence both for near and distant vision, the myopic diverging in distant fixation, the emmetropic in near. Sometimes, where the one eye is hypermetropic and the other myopic, convergent strabismus may exist for distant and divergent for near fixation; and in these cases there is not only not the ordinary transference of squint from one eye to the other, but there is instead convergence when one eye is occluded and divergence when the other is occluded. We must, therefore, in any case, look for the explanation of deviations from the typical conditions in the state of refraction of the two eyes.

What are the different facts to be noted in connection with convergent strabismus, and how are they to be explained? In the first place, the strabismus is not congenital. It usually develops between the ages of two and four, though in some cases it shows itself earlier, and in not a few later. A congenital convergent squint is of a different nature from the ordinary squint, and is due to paresis of one or both external recti.

In all such squints it is easy to distinguish two elements—a *permanent* one, constant in amount; and an *accommodative* one, or an increase of the deviation which only occurs on accommoda-

tion, and which is greatest for the fixation of near objects. The accommodative degree of squint remains practically the same always for the same distance of fixation. The degree of the permanent element, on the other hand, increases with time up to a certain extent, and then remains constant, sometimes again diminishing in later life.

In a very considerable proportion of cases of convergent strabismus the eyes are hypermetropic. The proportion in which this is the state of refraction is greater the younger the individual. On the other hand, but a very small proportion of hypermetropes squint. It is not uncommon to find in a family of hypermetropes of much the same degree, some who squint and some who do not.

In the great majority of cases there is found to be, in addition to hypermetropia, or independently of that refractive error, defective vision of the squinting eye. The defect is usually considerable, though it varies in amount in different individuals. It is rarely so great as to lead to eccentric fixation when the squinting eye is used on the occlusion of the other. As a rule, therefore, the squinting eye takes up fixation when the one usually fixing is covered. In some cases, indeed in most, in which the eyes are equally good, the squint is not unilateral, but alternating, and then the right eye is generally used for fixation to the left, and the left eye for fixation to the right.

Sometimes the strabismus is only periodic, and may even appear with tolerable regularity every second or third day, disappearing in the interval. There is then, generally, binocular vision, and consequently diplopia, during squinting. A periodic squint may, however, exist where binocular vision is impossible, owing to great defect of vision of the one eye.

Although a convergent squint usually develops slowly and gradually, it does sometimes happen that it makes its appearance quite suddenly.

The great characteristic of ordinary squint is its *concomitancy.*

In all convergent squints there is a more or less evident *restriction of the outward movement* of both eyes. But this restriction is never so great as the squint, *i.e.*, the angular defect in rotation outwards is not so great as the permanent angular deviation from the direction of correct fixation. In point of fact, its size is but a small fraction of that of the squinting angle.

The refraction in a convergent squint is sometimes emmetropic and occasionally even myopic. The so-called *strabismus convergens myopicus* differs from the ordinary concomitant

variety, in that no increase in the amount of squint takes place on near fixation. In fact, the abnormal manifest convergence at first only exists for fixation beyond the far-point, and is always associated with more or less troublesome diplopia.

We have now to inquire what it is that leads to strabismus. The proper explanation, in so far as the temporary accommodative element of the squint goes, was first given by Donders. In his study of the amplitude of accommodation, Donders found it necessary to distinguish between the total and the *relative amplitude of accommodation*, or the amplitude which exists for a definite degree of convergence.

Up to convergence on the binocular near-point there exists for every degree of convergence an amplitude of accommodation, part of which is what Donders termed the *negative* portion,—that is, all lesser degrees of accommodation which can possibly be associated with any particular degree of convergence,—and part of which he called the *positive* portion, which includes all the greater degrees of accommodation which may possibly be associated with the same state of convergence. Any degree of accommodation outside this range is not compatible with the binocular fixation of objects situated at the distance on which the eyes converge. Donders further found that accommodation can only be sustained for a distance for which the positive portion of the relative range of accommodation is not too small, as compared with the negative portion.

A hypermetrope has already to make an effort of accommodation in order to see distinctly at a distance. He therefore begins convergence with a defect of accommodative power, so that with increasing convergence his amplitude of accommodation proves sooner insufficient than in other states of refraction. Although he becomes, from habit, accustomed to associate a high degree, it may be, of accommodation with a slight amount of convergence, the positive portion of his relative range of accommodation may, to begin with, be too small, as compared with the negative portion, for even moderate degrees of convergence. Fatigue further reduces the positive portion, and eventually abolishes it altogether. The binocular near-point, therefore, recedes from the eye. The strained feeling in or about the eyes to which this gives rise in hypermetropes with binocular vision is what is now well known as *accommodative asthenopia*.

Hypermetropes have a way out of this difficulty. They may renounce binocular fixation altogether, and this is what some, though only a small proportion, actually do. In doing so they

squint. The one eye only is used for fixation, and the axis of the other crosses that of the first nearer than the object fixed. The conditions under which this is most apt to take place are such in which the value of binocular vision is reduced by defective sight in one eye.

The squinting eye is usually, as we have seen, found to have more or less defective vision. We may distinguish two forms of this amblyopia—(1) That in which central vision is retained; (2) that in which fixation is eccentric. The defect is mostly due to some optical imperfection (irregular and regular astigmatism, corneal or lenticular opacities, etc.). Sometimes there are changes in the retina. The amount of visual defect originally existing in the first form, and which leads under favouring conditions to the giving up of binocular fixation, is generally supplemented by a further degree of weakness of sight, due to the habitual suppression of the images received by the squinting eye. This is what has been called *amblyopia from disuse*. This element not unfrequently constitutes a very preponderating proportion, and sometimes, indeed, the whole of the existing amblyopia. It quickly disappears as soon as conditions are introduced which cause the attention of the individual to be directed on the impressions which the eye receives.

It used to be a habit with ophthalmic surgeons to recommend the tying up of the fixing eye from time to time, in order that the use of the squinting eye should be practised, and thus amblyopia avoided. Indeed, this is still practised by some oculists. It is, however, but one of the remains of the many inconveniences which have been imposed upon squinters in the way of treatment, and is almost always quite useless. Of this I am convinced, from the result of an examination made many years ago in a large number of cases, where, for a week or more at a time, the fixing eye, if hypermetropic, was disabled by the instillation of atropine, so that the patient was compelled to use the other for fixation. So soon as the fixing eye is liberated it takes up the work afresh, and the images on the squinting one are suppressed as before. Moreover, when from disease or accident to the eye which has previously been the master one, the other, from being the squinting eye, has to permanently assume the position of the fixing one, it soon regains all the power which it possibly can, whether it has previously been practised so many hours each day or allowed to remain for years without being used. It would appear that in some few cases the tying up of the fixing eye, by favouring diplopia, when it is again uncovered, may facilitate the re-establishment of binocular fixation after operation.

A true permanent amblyopia from disuse is denied by some, because they say that, for instance, cases in which cataract has existed for thirty or forty years have not been found to have suffered any loss of vision after a successful operation. There can be little doubt, indeed, that when central fixation has been once acquired, it is never lost by circumstances which merely interfere with the formation of distinct images on the fovea. It is otherwise, however, with cases in which cataract or any other opacity exists at the time that the supremacy of the fovea over other parts of the retina is properly acquired. When the cause is removed, although a certain amount of vision is restored, there is no central fixation. This is always the case in dense congenital cataract, and often, too, where there has been a long persisting dense corneal opacity following ophthalmia neonatorum. In the first case, after removal of the cataract, and in the second, even when all, or nearly all, the opacity has cleared away, the power of fixation is found to be defective, and always to remain so. In cases of unilateral strabismus which begin early in life, that is, during the first months, the squinting eye may be regarded as subjected to the same unfavourable conditions, as far as the acquirement of central fixation is concerned. Fixation with that eye is never called for, and therefore never acquired. The second form of amblyopia, namely, that in which there is no central fixation possible in the squinting eye, is in so far an *amblyopia from disuse*, in that it is occasioned by disuse at a time when central fixation is usually acquired. Besides the parallel cases of absence of central fixation from early disuse given above, there is one circumstance which argues strongly for the correctness of this view. We find, as already said, very frequently unilateral amblyopia where there is no squint, but rarely if ever an amblyopia without central fixation, *i.e.*, of course in cases where there are no objective signs to explain the absence of central fixation.

Apart, however, from amblyopia of one eye, there are some hypermetropic children who are so indifferent to the value of binocular vision, or rather one might say unobservant of, and not greatly inconvenienced by, the diplopia which its renunciation entails, that they readily adopt a squinting position in preference to asthenopia, and soon, by suppression, lose their diplopia. In this case the strabismus is mostly alternating.

It is by no means easy to account for, why there should be such a total suppression of the image falling on the squinting eye. It is easy to satisfy oneself that that portion of the field of the squinting eye which is not coincident with the field of the

other eye is constantly aware of the impressions it receives. The fact seems to be simply that in cases where there has never been binocular vision, and in which usually there is considerable congenital amblyopia, diplopia does not exist, whatever be the explanation. One can hardly draw any conclusions in cases of absence of binocular vision from what occurs when there has been binocular vision. In a number of cases, however, there is another reason for the absence of diplopia, namely, the fact that the squinting eye has acquired the habit of projecting its images in accordance with its position. In these cases there exists sometimes an imperfect form of binocular vision, but more frequently the absence of diplopia is due to the circumstance that, although there is no simultaneous elaboration of the two images of any object, still, whenever the squinting eye is conscious of its image, it is projected to the same place in space as that falling on the fovea of the properly directed eye; that is to say, there may be simultaneous vision with both eyes, and yet no binocular fusion of images in the true sense.

The two forms of suppression just referred to, although they hardly account for all the cases met with, are of interest so far as the conditions induced by operative interference are concerned. In the first form there is rarely any diplopia after operation, whereas in the second the operation gives rise to diplopia, of which the patient is more or less conscious. The new position of the eyes is not at first, or for some time, allowed for, and the position being relatively divergent, the persistence of the previous habit of projection results in more or less marked crossed diplopia.

In a few cases in which there is a considerable degree of latent convergence, but in which any manifestation of strabismus is always being prevented by the power of fusion, a manifest squint may suddenly develop. In such cases there is always diplopia, and the cause of the sudden manifestation of a hitherto latent condition is simply a loss of fusion power. This may be the result of some general bodily weakness, or of some cerebral disorder or disease. Thus, in children, continued irritation from teething or worms, or a sudden fright or severe fall on the head, not unfrequently leads to this manifestation of a hitherto latent squint (not always of a high degree), by directly interfering with the amplitude of fusion.

Sometimes, again, fusion seems to be strained to such an extent, to prevent the manifestation of a latent convergence, that any undue fatigue will cause the appearance of squint, with diplopia. I have, for instance, seen a child who almost daily

got a diplopia from this cause, and was in the habit of going to sleep for an hour or two to get rid of it. I have seen others in whom diplopia from concomitant convergent squint appeared periodically. In one case this occurred every alternate day, so that one day's squinting provided the rest that was required to overcome by fusion the tendency to over-convergence for the next day.

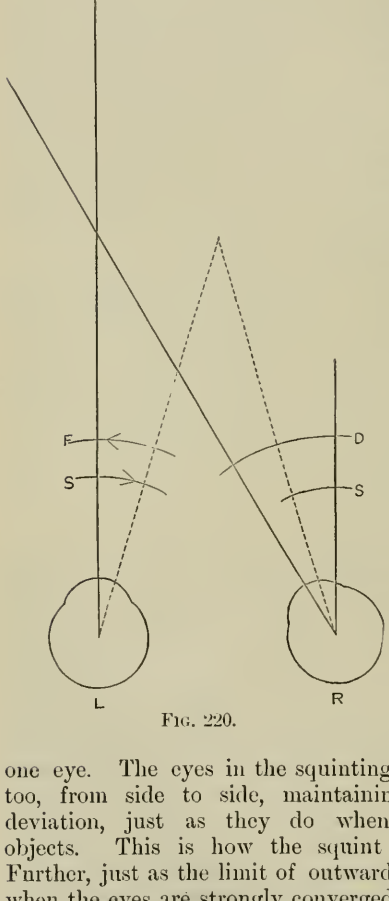


Fig. 220.

So far, then, as we have traced the development of squint, it has been that of the purely accommodative element, and the condition of the ocular muscles is in no way different from that which exists on binocular vision of a near object. The eyes, therefore, follow each other from side to side, just as they do when a near object at a constant distance lies successively in direction or another from them. Fig. 220 shows this. It will be observed that it only differs from Fig. 197 in that the axes cross nearer than the point of fixation. The deviation (D) is twice the angle of the squint (S), or the angle of excess of convergence. And the impulse to this excessive convergence is equally divided over both eyes, in the same way as is the impulse to convergence necessary for fixing a near object binocularly in a line with the one eye. The eyes in the squinting position follow each other, too, from side to side, maintaining all the time the same deviation, just as they do when fixing, binocularly, near objects. This is how the squint comes to be concomitant. Further, just as the limit of outward rotation is reached sooner when the eyes are strongly converged in binocular fixation than when no convergence of the axes is required, so it is with

concomitant convergent strabismus. This is the explanation of the real amount of restriction in the outward mobility of the eyes in a squint, which is often taken to be an indication of weakness of the external recti muscles. We have already seen that this defect in mobility outwards is always small when compared with the angular amount of squint. It is often apparently greater in the squinting eye itself than can be accounted for in the manner just explained. The reason for this, however, is want of habit. The squinting eye is never, under the conditions in which it is employed, directed very forcibly outwards, so that it requires an unwonted effort of will to bring it to its possible limit in this direction. This limit can, however, always be reached, although with more or less difficulty.

We have still to explain the nature of the permanent element of a convergent squint. If the squint arises on accommodation, under such conditions as have been described, why should any squint remain on cessation of accommodation? As a matter of fact, there is only an accommodative squint to begin with; the permanent element slowly develops. This latter has often been, and in fact is very generally still, assumed to be due to structural changes taking place in the internal rectus of the squinting eye, whereby it becomes permanently shortened. Many authors assume at the same time a weakening or so-called insufficiency of the externus from disease. The evidences against such an assumed structural change taking place are so strong that to my mind they are absolutely conclusive. I need only refer to three of the most important:—

1. The temporary disappearance of the squint under general anæsthesia, as well as its occasional gradual disappearance in adult life;

2. The perfect concomitancy of the squint, even when it is mainly of a permanent nature; and,

3. The absence of any anatomical demonstration of structural changes in the muscles.

As to the first, one invariably sees, when the anæsthesia is sufficiently deep, that the effect of a tenotomy is much greater than it proves to be after recovery from anæsthesia. Occasionally, too, a squint disappears altogether under anæsthesia, without operation.

Stress has already been laid on the fact that any weakening of a single muscle must of necessity render concomitancy impossible, and introduce conditions comparable to paresis. After tenotomy, for instance, concomitance is lost, and it is long before it is approximately regained. When the tendon of the right

internal rectus is separated from its attachment to the sclera for convergent squint, the deviation, which before was the same for all directions, now constantly diminishes for fixation farther and farther to the left, and constantly increases for fixation farther and farther to the right.

As to the third point, to which, however, I do not attach so much importance, it does seem significant that, notwithstanding the abundance of material which is to be found everywhere, no one has as yet brought forward either macroscopic or microscopic evidence of structural change in the muscles.

To what, then, is the permanent element of the convergent strabismus due? There can be little doubt that it is simply the gradual persistence of the increased and abnormal degree of convergence which is constantly brought into play by the accommodative squint. This explanation, that the permanent as well as the accommodative element of a convergent strabismus is simply an increased innervation to convergence, was first given by Hansen Grut. The habit of converging leads gradually to a withdrawal, from the voluntary disposal of the individual, of a greater and greater amount of the amplitude of convergence. This he has expressed as follows: "The constant habit of convergence displaces the functional position of rest more and more inwards."

The various facts just referred to point to convergent squint being entirely innervational, while the result of the examinations under different conditions of the latent position of the ocular muscles, in individuals who have retained binocular vision, points to the strong tendency that there actually is for convergence to persist in the manner in which it is constantly called into play. This being the case, it is not difficult to understand how, when convergence is overstrained from any cause, a permanent squint may develop in other states of refraction than hypermetropia. Certainly hypermetropia is much the most common predisposing cause; but excessive use of the eyes may, in emmetropes and also in myopes, lead to a latent convergence, which may in turn, though much less frequently, develop into a manifest strabismus. Over-convergence may, for instance, be induced in any condition of refraction by paresis of accommodation. The existing relation between accommodation and convergence is then interfered with, and the defect in accommodative power unconsciously counteracted as far as possible by too powerful convergence.

In the interesting variety of convergent strabismus in myopia the development may be followed through its different stages.

An uncorrected or imperfectly corrected myope, who is in the habit of reading for long periods on end, finds that, for some time after he has ceased to read, distant objects, if seen sufficiently distinctly to attract his attention, appear double. At first this doubling of distant objects is only temporary. After some time it becomes permanent, because of the greater persistence of convergence, and because, vision being less perfect for distance, fusion does not exert so powerful an influence in overcoming this convergence innervation. After a longer and longer time the distance at which objects appear in homonymous double images becomes shorter and shorter, and eventually a squint, at first only manifest beyond the far-point, has reached inwards until it exists for nearer fixation. In this variety of convergent concomitant squint there is, however, always this difference as compared with the hypermetropic squint—that no increase in the angular deviation takes place for near fixation.

To sum up in a few words, the nature of convergent concomitant strabismus, we may say that it is *the active state to which the equilibrium of the muscles leads when the interni have for long continued to receive an abnormal degree of innervation to convergence.*

In the *treatment* of convergent strabismus we have to take into consideration the fact that there is a tendency to a gradual disappearance of the squint as the patient grows older. When this does occur, it is seldom before the tenth year, and generally considerably later. The nature of the squint, too—whether periodic or constant, relative or absolute—must influence the treatment; so also must the state of vision in the squinting eye, and the presence or absence of diplopia. Usually when some operative measure is required, the degree of the permanent squint will afford an indication as to what operation, or combination of operations, is advisable.

Though much can be done in some cases without operation, the cure of a convergent squint can usually only be thoroughly made by bringing about an alteration in the relative positions of the tendinous attachments of the lateral muscles. The permanent element of the squint can only be cured in this way, whilst that portion which is accommodative often disappears under the altered conditions brought about by proper correction of the existing error of refraction. When the squint has begun late and has not existed long, and where there is either spontaneous or easily elicited diplopia, with not too high a degree of amblyopia of the squinting eye and hypermetropia, an attempt should be made to cure it by causing the patient to wear glasses which as

nearly correct his hypermetropia as he will tolerate. By keeping the accommodation paralysed for some weeks during the first wearing of the glasses, a pretty full correction may often afterwards be permanently worn without inconvenience, and a favourable effect on the squint at the same time obtained. Owing to the difficulty of giving spectacles to young children, it is only a small proportion of cases in reality which admit of purely optical treatment.

The continued use of atropine for the purpose of keeping the accommodation paralysed in both eyes, and thereby avoiding the tendency to squint, is sometimes useful in the case of quite young children.

The operations of tenotomy of the internus, or advancement of the tendon of the externus, only produce an alteration in the mechanical consequences of the existing relation between the power of the two lateral muscles, but do not influence in any direct manner the cause of the squint. That is to say, that by displacing the attachment of the internal rectus backwards, or that of the external rectus forwards, the initial position of the eyeball is altered in such a manner as to introduce a state of less convergence of the two axes. In this way the appearance is improved, while sometimes at the same time a resumption of function, which the abnormal convergence rendered previously impossible, is permitted. Still the conditions of innervation, which are the cause of the squint, remain.

Indirectly, the operative effect may lead to a true cure of the squint, by so far diminishing the abnormal muscular conditions that the further difficulties can be more or less readily overcome by fusion. When this happens, there must have previously existed binocular vision. The latent or dynamical deviation always remains. Whether the full permanent amount of the squint, or even more, should be corrected by operation depends on the age of the individual, as well as on the existence or not of circumstances which help to maintain the correction when once effected. The object of the operation is not merely to correct the position of equilibrium, but also to do so as far as possible in such a manner as shall admit of the accommodative and associated movements of the two eyes taking place in the normal way.

In operating on children with hypermetropia and amblyopia of one eye, we should leave a little of the convergence uncorrected, owing to the possibilities of a change, in the direction of spontaneous cure, taking place as they grow. In adults we may usually safely correct the whole amount of permanent squint,

even where, as is often the case, there is no possibility of their obtaining binocular vision after operation. In cases where the conditions favouring the simultaneous use of the two eyes are more advantageous, and at the same time the degree of convergence associated with accommodation is clearly in excess of the normal, it is advisable to correct the full permanent element. In alternating squints, too, the whole correction should be made.

When the convergent strabismus is associated with myopia, and is only relative, that is, only existing for fixation beyond a certain distance, care has to be taken that the correction of the squint for a distance does not give rise to insufficiency of convergence for near objects. Such insufficiency would either introduce relative divergence, with diplopia, for near vision, or asthenopia, owing to the too great effort necessary to keep up the required amount of convergence. With correction of the myopia, I believe this danger need seldom be feared, so long as the position for a distance is not over-corrected. It is well, however, to determine beforehand whether there is any latent convergence at the reading distance. Should there be, there can be absolutely no doubt as to the advisability of performing a tenotomy.

In the immense majority of cases the most successful operative interference leads only to a removal of either the whole or, at all events, the unsightly portion of the abnormal convergence. The effect, so far as the eyes are concerned, is only cosmetic, and it is rare, comparatively speaking, that any true binocular vision results. Different methods have been devised for the purpose of stimulating the desire for fusion of the two images. Possibly these may in some cases be productive of the desired effect. In most cases they are, however, altogether useless; and it is indeed doubtful whether, in the few cases in which binocular vision returns, the cure would not have been just as rapid without their aid. The best test for the presence of true binocular vision, or the accurate appreciation of the third dimension, is that which is known as Hering's. When a prism of say 4° to 6°, with the angle directed inwards or outwards, held in front of either eye while the other is fixing any object, gives rise to a convergent or divergent movement of that eye, we may conclude that binocular vision of some kind exists.

Divergent Strabismus.

The most frequent state of refraction met with in this form of strabismus is myopia. But the preponderance of myopia is not

so marked here as that of hypermetropia in concomitant convergent strabismus. It is a common enough occurrence in cases of more or less blindness of one eye, especially where the condition causing the blindness has arisen in adult life. The divergence develops, as a rule, slowly; sometimes suddenly, but only then in some cases of sudden uniocular blindness. The degree differs somewhat in different cases, but seems at the most to be from 10 to 12 metre-angles. It is never as high as that met with in complete internus paralysis, or after an unsuccessful tenotomy of the internus by Dieffenbach's method, a kind of case which is now very rarely seen.

It is often at first, and may for long remain, relative only, *i.e.*, there may be a manifest divergence for near vision, but no absolute divergence. Marked relative manifest divergence may be said to be peculiar to myopia. It is always associated with more or less complete absence of converging power.

After the divergence has become so far established that it is absolute, and binocular vision is lost for all distances of fixation, it is found that little or no convergent movements can be made; whereas not only is lateral mobility retained, but lateral movements take place in such a manner as to leave the deviation unaltered in extent for all directions of fixation. This characteristic concomitancy is, then, a proof that there is no actual muscular defect. In fact, it is sufficiently evident that whereas, as in convergent concomitant strabismus, there is an active innervation to over-convergence, there is in divergent strabismus more or less complete absence of innervation to convergence. There is, therefore, no insufficiency of the interni, only an *insufficiency of convergence*. The convergent impulses are gradually lost from disuse. In the case of high myopia it is more or less difficult or impossible for the eyes to maintain a sufficient degree of convergence to fix objects binocularly at the far-point. Relative divergence, therefore, which is what is first manifested, gradually passes into the absolute form, because, owing to the defect of distant vision, double images are readily disregarded. The fact that under these circumstances, however, there can ever be absolute divergence, shows that the functional position of rest of the eyes, in the constant enfeeblement or absence of convergent impulses, is a divergent one.

The divergent deviation shows itself on one eye alone, for the reason that, binocular fixation being impossible, one of the two diverging axes must be directed on the object on which attention is directed. This necessitates a movement inwards of the fixing eye, with which is associated an outward movement of the other.

This is shown in Fig. 221. The condition is, in fact, the exact counterpart of that shown in Fig. 220.

Divergent squint differs, however, from convergent squint in another way. There is no active contraction of the externi in divergent, as there is an active contraction of the interni in con-

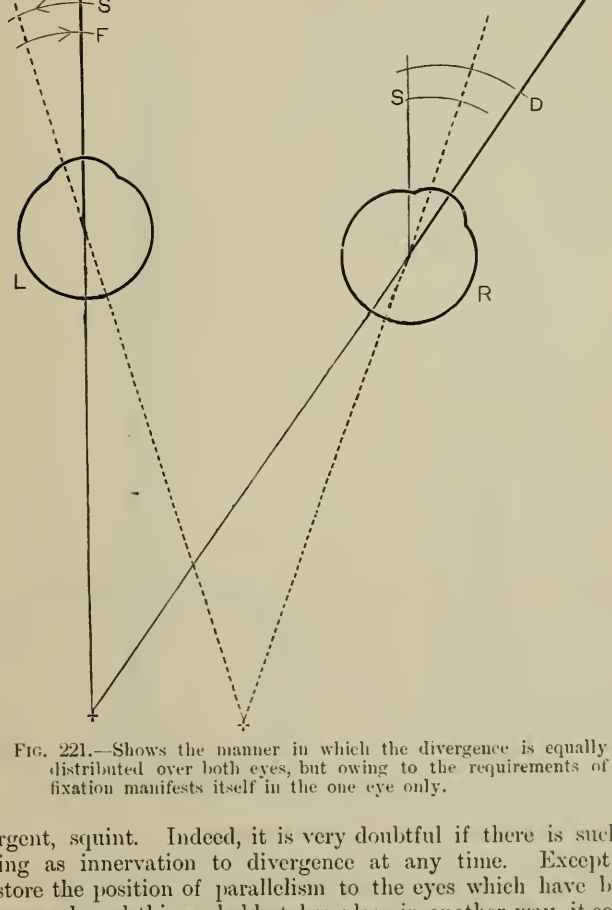


FIG. 221.—Shows the manner in which the divergence is equally distributed over both eyes, but owing to the requirements of fixation manifests itself in the one eye only.

vergent, squint. Indeed, it is very doubtful if there is such a thing as innervation to divergence at any time. Except to restore the position of parallelism to the eyes which have been converged, and this probably takes place in another way, it could serve no useful purpose in vision.

Divergent concomitant strabismus is, in fact, *the passive state to which the equilibrium of the muscles leads when the internal recti receive little or no innervation to convergence.*

Strabismus operations. — There are various methods in use of performing both tenotomy and advancement. These, whilst differing somewhat in minor details, are the same in principle. Tenotomy is now always performed by cutting across the tendon of the muscle close to its insertion to the sclera, according to the method introduced by von Graefe. This permits of a certain degree of retraction, but the presence of other indirect attachments prevents the retraction being too great.

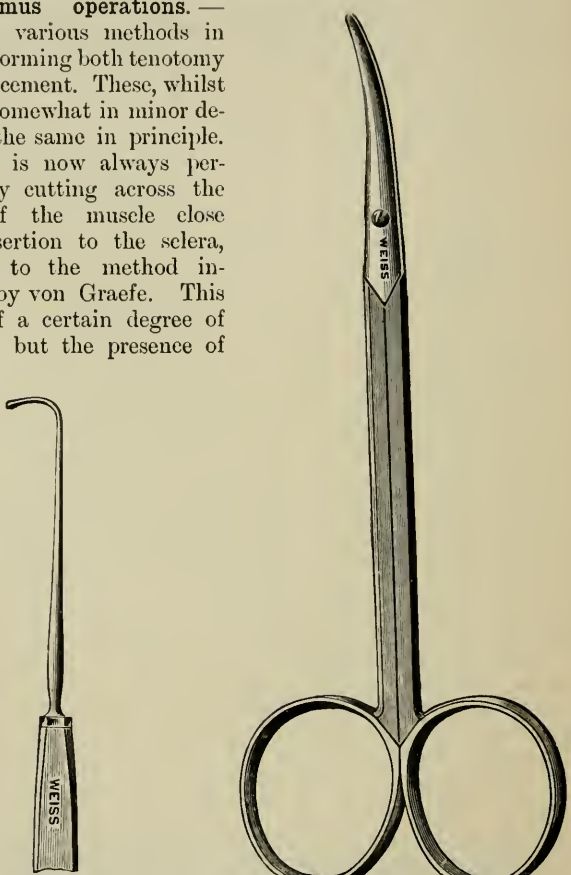


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FIG. 222.—*a*, Strabismus hook ; *b*, strabismus scissors.

The instruments required for the operation (Fig. 222) are a

speculum, or a couple of Desmarres' elevators, fixation forceps, a pair of blunt-pointed scissors (curved on the flat), and a strabismus hook. A tenotomy can generally be performed without general anæsthesia. A drop or two of a 5 per cent. solution of cocaine produces sufficient local anæsthesia, as a rule; and it is better, in order to be able to judge of the effect of the operation, that the patient should be fully awake. In performing tenotomy of the internal rectus of the right eye, or the external rectus of the left eye, the surgeon stands behind the patient's head. For the other lateral muscles he may stand in front at either side—preferably the left. After having inserted the speculum, a hold is taken with the fixation forceps of a piece of conjunctiva lying over the insertion of the muscle, a good quarter of an inch therefore from the border of the cornea. A vertical snip is next made with the scissors, large enough to allow the blades to be opened pretty freely underneath the conjunctiva. The scissors are then made to cut their way backwards immediately underneath the conjunctiva until they cease to encounter any resistance, and one is able to feel that their points can be freely moved about. The scissors are then withdrawn, and the hook inserted underneath the muscle. This is done by first passing it backwards along the upper or lower edge of the muscle, according to the one operated on, in such a way that its horizontal and convex portion is parallel with that edge. On then turning it quickly round, it slips below the muscle and is drawn forwards until it is arrested by the attachment of the tendon. It is then transferred to the left hand, and the tendon cut between the hook and the eye. After this has been done, the hook is again inserted and swept upwards and downwards, with the object of testing whether the division has been complete. If it should catch on any portion of the insertion which has escaped division, this portion must be divided with the scissors. A suture is then used to bring the edges of the wound in the conjunctiva together, and to prevent subsequent sinking of the caruncle, which, when it occurs, is very unsightly. The suture should be passed *diagonally downwards and inwards*, and only take in the conjunctiva. A deeper suture placed horizontally is sometimes required if the effect of a tenotomy has been too great. The eye should afterwards be bathed occasionally with corrosive sublimate lotion, but no dressing is required.

Operation for advancement of a rectus muscle. — A vertical incision is made with scissors in the conjunctiva over the muscle to be advanced, and slightly posterior to the site of its tendinous insertion in the sclera. The length of this incision should be fully equal to the breadth of the muscle. Taking

hold of its posterior lip, a piece of conjunctiva of an approximately crescentic shape is then removed. The tendon of the muscle is next taken up on the strabismus hook, as in the performance of tenotomy. Holding the tendon forward on the hook in the left hand, the smooth branch of a pair of advancement forceps (Fig. 223) is passed below it. The forceps are then closed, and thus obtain a firm hold of the tendon, while the hook is at the same time withdrawn. Transferring the forceps to the left hand, the tendon is divided at its insertion. Two sutures are then passed through the muscle, and at the same time through the superjacent tissues (which are drawn forward by an assistant). The sutures are entered from the under surface of the muscle at some distance posterior to the portion which is grasped by the advancement forceps. The free end of the tendon is then excised by a snip with the scissors made immediately behind the forceps. The other ends of the two sutures are next passed under the anterior portion of the conjunctiva, the one on a level with the upper, the other with the lower, edge of the cornea. The two ends of each suture are now knotted together, by which proceeding the muscle is drawn forwards towards the cornea.

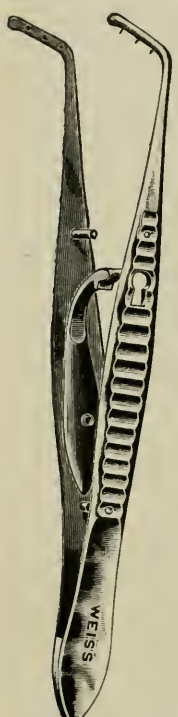

Fig. 223.— Prince's advancement forceps.

The effect of this operation depends entirely upon two points: the firmness of the hold which the threads have of the tissues near the cornea, and the avoidance of any slipping in tying the knots. To ensure the first requirement, the needles at the ends of the threads, which are used to carry these below the conjunctiva, should be passed deeply, traversing the superficial layers of the sclera. The effective knotting is got, on the other hand, by an assistant grasping the first twist of each knot firmly, after it has been pulled tight with a fine pair of ribbed forceps, before the second twist is made.

Effect of Tenotomy and Advancement.

Of the two forms of concomitant squint commonly met with, the one, as has been seen, is an *active* and the other a *passive*

condition. It is this essential difference which accounts for the difference in the effect gained, as a rule, by tenotomy of the internus for convergent strabismus, and tenotomy of the externus for divergent strabismus. Tenotomy of the internus, which is actively contracted under an impulse to convergence, is followed by retraction of the muscle. It forms, in consequence, an adhesion to the sclera posterior to that which it formerly had, and that equally, whether the tenotomy be performed on the squinting or on the fixing eye. Tenotomy of the externus which is in a passive state (beyond the amount, which possibly varies in different cases, of its tonic innervation) is as a rule followed by little or no retraction, so that a new attachment to the sclera is formed, in the absence of any convergent power, at much the same place as that from which the separation was made.

Further, the cause of the squint continues in both cases after operation, although the effect of the position of the eyes is altered in the first case, and not generally in the second. This being the case, the continuance or increase of convergent innervation may in the course of time lead, after an operation in which a good position has been obtained, to a return of convergent squint. Or, again, the discontinuance or diminution of convergent innervation, after a similar operative result, may lead to divergence. The improvement in position at the time, however, is one which is effected for all distances of fixation.

If, instead of tenotomy of one or both externi, the internus of one or both eyes be advanced, and caused to form a new attachment closer to the cornea (or shortened, while retaining much the same line of insertion), we get, in the absence of converging power, a new position of functional rest; and the position thus got does not tend to be lost, unless the divergence previous to operation had not attained its full development. On the other hand, the position, though improved for distance, will not generally be at the same time corrected for nearer fixation. The effect of strabismus operations is in most cases only a cosmetic one. The cases in which a more complete cure of squint is obtained are mostly those in which, with equal, or fairly equal, vision in the two eyes, the squint has developed not too early in life. Such a cure is, for instance, the all but constant result of tenotomy for the convergent squint of myopes. It is not so very uncommon, too, in the later-developed convergent squint of emmetropes and hypermetropes, especially if the squint has been accompanied by diplopia. Again, it is got by operation on divergent squints, when the vision of the deviating eye is sufficiently good on optical correction to excite fusion.

It is, first, the establishment of a more normal relation between the two axes by a suitable operation, and second, the proper optical correction of the two eyes, that render binocular fixation possible. In cases, too, in which the complete cure of the squint is effected, it is got for the most part as soon as these two conditions are complied with. The use of stereoscopic exercises may possibly in some cases help. It is doubtful, however, if such exercises ever really lead to the establishment of binocular fixation where this would not take place without their aid.

As to operations on the lateral recti, one should be guided by the following principles:—As regards convergent strabismus, it is not advisable to attempt the correction of anything but the permanent or habitual element of the squint. Cases should not, therefore, be operated on too young, as it is generally long before an accommodative over-convergence leads to such an inveterate habit of convergence that a large portion of the excessive convergence persists, notwithstanding optical correction, when, as is usually the case, such correction is required. Owing to the fact that the age at which the squint first develops is not constant, and also because the habit of persistent squinting is more readily acquired in some than in others, no definite age can be fixed which is applicable to all cases. It is a good rule, and one which should only be departed from under exceptional circumstances, not to operate before the age of six. The younger the individual, too, the more careful should one be, especially in hypermetropes, not to make too full a correction by operation, but to leave something to disappear in the course of time by the use of suitable glasses.

This precaution is not so necessary in alternating convergent squint, with emmetropia and good vision in each eye, and not at all necessary in *strabismus convergens myopicus*. In the former, and even in cases otherwise similar in which the refraction is hypermetropic, there is a good chance of binocular vision being resumed after operation. In the latter, this restoration of binocular vision is all but invariable. Every now and then one finds the result of a single tenotomy much greater than might be expected (the average effect is about 5 metre-angles). The cause is, then, that the retraction of the divided tendon has sufficiently reduced the over-convergence to allow fusion to do the rest that is required to render binocular vision possible. There remains, then, always more or less latent convergence, and this may, with advantage, be accurately corrected by further operation. It may even, without harm, be to some extent over-corrected. But as nearly accurate correction as is possible

by tenotomy, and a restraining suture if necessary, should be aimed at.

Periodic squints, on the other hand, should not be interfered with. In these cases optical treatment is alone called for.

In the case of divergent squint, the full correction may be safely made by advancement of one or both interni in all cases in which there is no convergence left. Where there is fairly good convergence, care must be exercised, as it occasionally happens that even a tenotomy of one externus may give an over-correction.

Latent divergence need only be corrected, by advancement of one or both interni, when it is considerable (5 metre-angles or over). On no account should slight latent deviations, either divergent or convergent, be touched.

The fact that concomitant squint, whether convergent or divergent, is a binocular and not a uniocular defect, justifies the division over both eyes of the operative effect aimed at for its correction.

It is not advisable, practically, to operate on both eyes in cases where a single tenotomy or advancement (performed first on the squinting eye) is sufficient to rectify the position. When this is not sufficient, the next step should always be to perform the similar operation on the other eye, restricting its effect, if necessary, by suture. In this way we avoid too great an operative insufficiency. For instance, in convergent strabismus of the right eye we may begin by tenotomy of its internus, and increase the effect, if necessary, by tenotomy of the left internus. This is preferable to further altering the position of the right eye by performing advancement of its externus, a proceeding which is sometimes advocated.

The operations should succeed each other as follows—(1) Tenotomy of right internus, with or without restraining suture; (2) tenotomy of left internus, with or without suture; (3) advancement of right externus; (4) advancement of left externus.

Nystagmus.

Nystagmus is the name given to involuntary oscillatory movements of the eye. The movements are mostly from side to side, but may be rotatory or almost entirely vertical. They are generally constant, but increase in intensity with attempts at fixation, or when the individual is in any way excited. In some cases the nystagmus only exists for certain directions of fixation, most frequently when the eyes are directed upwards. There is always

some degree of jerky or nystagmic movement whenever the eyes are forcibly turned in any direction, and an attempt made to maintain them for any length of time in what corresponds to the boundaries of the physiological action of the respective muscles. Nystagmus is consequently a frequent symptom in ocular paralyses, when the eye is moved in the direction of the weakened muscle.

Most cases of nystagmus are developed in early life as the result of defective vision, at a time when the movements of the eyes suited to the requirements of fixation would otherwise be acquired. The education of the co-ordinating centres is thus imperfect. Sometimes these centres appear to be primarily affected, but little is known as to the cause of this. Very early acquired nystagmus is never associated with any subjective symptom of the dancing of objects in front of the eyes. This is no doubt mentally suppressed, in much the same way as is the diplopia in an ordinary concomitant convergent squint developed early in life. The condition is altogether incurable. Nystagmus may be acquired in after life as the result of changes in the nerve centres, or as a consequence, it would seem, of some altered states of innervation, brought about by abnormal conditions of illumination and fixation.

A common variety of acquired nystagmus is what is called *miners' nystagmus*. In this condition the irregular involuntary contractions take place mainly or entirely in looking upwards, and are associated with the subjective symptom of a corresponding rapid movement of external objects which is very disturbing. There can be little doubt that miners' nystagmus is caused by the tiring of the ocular muscles, which are overstrained owing to the constrained position in which the eyes have to be maintained by the miner at his work. Later acquired nystagmus causes an unpleasant subjective symptom of external objects dancing in front of the eyes. Snell has shown very conclusively that it is only developed in those whose work is of such a nature as to necessitate the strained position of fixation. When this constant straining is given up, the nystagmus slowly passes off. In this respect the miners' nystagmus differs from that which is acquired, owing to defective vision, in early life.

Muscular Asthenopia.

Difficulty, more or less pronounced, in sustaining the effort of seeing near objects is mainly met with in cases in which there is binocular vision. As a general rule, whenever this has been

given up, asthenopic symptoms of the ordinary kind are absent. This is so whether the uniocular fixation, which then takes place, is associated with any apparent squint or not.

Accommodation and convergence are most frequently both necessary for the distinct binocular vision of near objects. Consequently, it would perhaps not be unnatural to assume that asthenopia might result from weakness or exhaustion either of the ciliary muscle or of the internal recti muscles. Such an assumption, however, is found to require some modification. Accommodative asthenopia, and the somewhat similar symptoms referable to uncorrected astigmatism, have already been referred to, and their causes discussed (see p. 484). There is in the first place no sufficient evidence that weakness of the eye muscles themselves is ever the cause of symptoms of inability to sustain an effort of reading or other near work.

When there is any actual weakness in an eye muscle, or in its innervation, from over-strain or paralysis, we find as a consequence nystagmus. Possibly also the much rarer conditions of "spasm" have a similar causation. It is true, no doubt, that in many cases the irregular or nystagmic action of the weakened muscle may only assert itself for fixation in a direction corresponding to the limit of its action. Still it is always easy to elicit this evidence of muscular weakening. Nothing of this kind, however, is met with in the condition which is usually diagnosed as muscular asthenopia. Besides, any real muscular weakening necessarily leads to a loss of concomitancy in the associated movements in which it takes part.

Muscular asthenopia, if the term has any justification at all, must therefore be caused by a weakening of some other kind. The well-recognised accommodative asthenopia depends, as we know, not upon any weakness of the ciliary muscle, which is often, on the contrary, stronger than usual, but on an unsuitably disposed amplitude of relative accommodation. In the same way there are possibly cases of asthenopia which depend upon an unsuitable disposition of the amplitude of relative convergence. And these cases might on the same principle be referred to a category of *muscular asthenopia*.

At first sight it might seem that relative accommodation and relative convergence were interchangeable terms. This is not the case, however, as the starting-points of accommodation and convergence are not invariably the same. On the one hand, the state of refraction determines the starting-point of accommodative effort. On the other hand, the effort of convergence is possibly related in some measure to the point from which con-

vergence has to be started. In other words, it may depend upon the latent position—the position of physiological rest, which may be parallelism, more or less divergence, or even convergence, of the two visual axes.

Nevertheless the effort to properly co-ordinate and sustain accommodation and convergence must be of much the same nature, whether the cause of an existing difficulty is primarily an unsuitable disposition of relative acccommodation, or of relative convergence.

Theoretically, one might expect that any deviation from the ideal or emmetropic starting-point of accommodation would cause difficulties which in the long run must give rise to asthenopic symptoms. Practically, however, this is not the case. This is because the ideal relation between accommodation and convergence is, as we have seen, far from being the rule. That there is a more or less intimate relation between these two impulses is shown by the fact of convergent squint occurring at all. But that the relation is different in different people is evident also from the study of latent deviations. Habit, in cases of ametropia, tends to establish quite a different relationship between accommodation and convergence than that which is looked upon as ideal.

It is important to bear in mind that, in connection with the association of the two eyes, one has to do mainly with the function of convergence. It is reasonable enough to suppose that asthenopia, met with in a case in which there is a high degree of latent divergence, may be ascribable to an unsuitable disposition of relative convergence. It has to be remembered, however, that asthenopic symptoms are by no means constant even in cases presenting a high degree of latent divergence. It used to be a very common thing, on the initiative of von Graefe, to operate on these cases of purely latent divergence. But in many cases, notwithstanding that a perfect operative result is obtained, no cure of the asthenopia results. Others may be relieved at the time, but the symptoms afterwards return without any recurrence of the latent divergence. It is therefore illogical to ascribe the temporary cure in these cases to the alteration caused by the operation. The operation may even cure by suggestion alone, and by the rest and change which it entails. Such a cure, too, may be permanent, though it is usually only temporary.

This being the case in the higher degrees of latent divergence, operations are certainly unjustifiable in the slighter degrees of the same condition.

It is the idea that a latent divergence or a latent convergence, however small, is an evidence of a defect in muscular balance which has led to operative interference. This same idea has given rise to the terms *exophoria* and *esophoria*, which, however convenient they may be, are certainly less appropriate than *latent divergence* and *latent convergence* which have for long been in use. Besides, the idea is undoubtedly an erroneous one. Anyone who is convinced of this could not or ought not, therefore, to operate for anything but the higher degrees of deviation, which admit, at all events, of operation in a legitimate manner.

The ease with which even the slightest deviations can be detected, coupled with the muscular insufficiency idea, has led to much greater importance being attached, in some quarters, to latent divergence and convergence than these conditions deserve.

With regard to outward and inward deviations, it has to be remembered that the convergence innervation is of a different order, as it were, from that which governs associated movements of the eyes in the same direction. Convergence is practically mainly a reflex action: the associated movements are both reflex and voluntary. Convergence seems to be established in each individual more exclusively by fusion,—the desire for binocular vision. It thus comes to be associated more or less intimately with innervation to accommodation. Changes in refraction necessarily disturb the suitability of this association. But the association is never sufficiently close to altogether resist alteration. It is, consequently, mainly the more rapid refractive changes which disadvantageously disturb the relationship which fusion has established. Moreover, convergence is more or less easily unlearnt. When conditions, such as uniocular blindness or amblyopia, make binocular fixation impossible, the call for convergence is absent or weakened, fusion no longer comes into play, and eventually all efforts at convergence are given up, and it becomes impossible to elicit it in any way.

But there are great individual differences in the force and continuation of the *habit* of convergence. The degree of *persistence* of an innervation to convergence, in the absence of any necessity for converging, varies in different people. This may no doubt, to some extent, depend upon the intimacy of its established relation to accommodative impulses. The study of physiological latent deviations clearly shows this individual difference in similar refractive conditions. All these facts, the experimental evidence of which has already been given, afford sufficient reasons for not ascribing any importance, as a rule, to such deviations.

There seem also to be individual differences in the strength of the fusion tendency. Certainly in some cases a weakness of fusion must be looked upon as pathological. In such cases, whatever may be the cause, it is important not to ascribe the symptoms to the muscles themselves.

In addition to the determination of latent deviations, there is another kind of investigation often made in connection with the movements of the eyes from which wrong inferences are very generally drawn. I refer to the determination of the limits of movement in different directions. When the examiner fails to elicit a movement in some particular direction, equal in amount to the supposed normal, this is often taken either as a weakness of the muscle which produces movement in that direction, or, at all events, as a defective muscular balance due to preponderating strength in its antagonist. Where there is evidence of paresis, as shown by a disturbance of association with the muscle or muscles which produce the same direction of movement in the other eye, this explanation is no doubt justified; and this even where the disturbance is so slight as to be masked by fusion, and only to manifest itself latently. In the absence of paresis, however, the inference is erroneous.

Attempts, too, which have often been made to measure the possible excursion with minute accuracy are hardly scientific. They often only show a failure to appreciate the essential difference between the possible accuracy which may be got from a physical measurement as opposed to what can be expected from most physiological measurements.

Take again convergence. How easy, is it not, for different observers, or even the same observer at different times, to elicit in any particular case varying degrees of convergence? There must be an effort made on the part of the patient to strain the innervation to convergence to its full amount, before relaxing it, in order to effect a maximum convergence. Much, therefore, depends upon the examiner, and the determination with which he induces this effort in his patient. Many cases, indeed, of supposed weakness or insufficiency of convergence are merely the expression of a weak innervational effort. No doubt there may often be some degree of general neurasthenia, which makes it more difficult to induce the convergence effort. A determined attempt, however, on the part of the examiner will usually readily cause the effort to be made.

Such cases of weak innervational effort must not be confounded with the much rarer cases of really weakened innervation, paresis, or even paralysis of convergence. Are we to

relegate all cases of weak convergence associated with asthenopia to the category of muscular asthenopia? If so, is this a form of muscular asthenopia in which real and lasting benefit is to be got by operative interference? Here, again, if we adhere to the term muscular asthenopia, it must be as a convenient expression, for what we know is not really a muscular defect, not insufficiency of the interni, but a particular form of innervational defect. It may be a more convenient term than, *e.g.*, *non-paretic convergence insufficiency*, which, however, is certainly more appropriate.

As a general rule, operations for this kind of muscular asthenopia should not be rashly undertaken. Rest, in the shape of restricted use of the eyes for reading, etc., general tonic treatment, and massage is what is indicated in most cases. Abducting prisms, alone or combined with convex lenses, may then be tried. Indeed, from the aid which may be expected from "suggestion" alone, as I have already hinted, it may often be useful to prescribe such glasses early in the treatment. Operation, and preferably, I think, capsular advancement of both interni, should be reserved for cases which resist this treatment. But it is absolutely essential that operation should be confined to cases which present a sufficient margin of facultative absolute divergence to prevent the possibility of resulting convergence.

There remains one other class for consideration, namely, cases of *latent vertical deviation*, what is now pretty generally called *hyperphoria*. The asthenopia which may be associated with hyperphoria may also, appropriately enough, be called a muscular asthenopia. In my experience, although I invariably look for it, hyperphoria is by no means a frequent cause of asthenopia. To judge, however, from the numerous references to this form of asthenopia in American literature, it would appear to be very common. But then it must be remembered that even slight degrees of "exophoria" and "esophoria" are also taken to be the cause of asthenopia. For reasons already referred to, this must be looked upon as a mistake. Certainly slight hyperphoria is often unassociated with any kind of inconvenience. On the other hand, when it amounts to only two or three degrees, or even less, binocular fixation is less easy, and in some cases an appreciable strain is put upon the regulating innervation of fusion. Asthenopic symptoms consequently result if binocular fixation is persisted in, or a manifest deviation, which from its small degree may not be very noticeable, occurs when the strain of binocular is given up for uniocular fixation, and thus asthenopia avoided.

There is a not uncommon association of vertical displacement with convergent strabismus. It seems probable that in some cases, particularly where there is no marked amblyopia of the squinting eye, the manifest convergent squint may actually be in a manner due to a pre-existing hyperphoria. Without the presence of this height difference, the conditions favouring over-convergence might be overcome by fusion. This would be analogous to the frequent association of an ocular paralysis with a latent lateral deviation.

Physiologically there is comparatively great difficulty in overcoming vertically placed prisms in front of one eye in the interest of binocular vision. It is therefore natural that slight latent lateral deviations should not cause the same strain on binocular fixation as vertical deviations may do, and actually do.

But there is another question to be considered. Are vertical deviations of the same nature as lateral deviations? Confusion on this point, along with the apparent similarity of causation which is suggested by the current nomenclature exo-, eso-, and hyperphoria, and the ease with which these deviations are detected, appear to me to have led to not a little misconception. If latent lateral deviations are not to be considered evidences of muscular weakness or of defective "muscular balance," are we also to exclude an origin of this kind in the case of vertical deviations?

Latent lateral deviations we have referred to the existing individual state of physiological (innervational) equilibrium in the position of the eyes which is detected in the temporary absence of binocular fixation. They are therefore expressions of a state of innervation, and vary according to the greater or less persistence of convergence innervation after the main controlling influence of fusion has been withdrawn. Latent lateral deviations are, moreover, by no means constant. They vary with the length of time during which binocular vision has, in the course of testing for them, been in abeyance. They vary also according to the particular conditions under which the eyes have been used immediately before the test is applied. Thus at first, at all events, the amount of deviation is different, if tested after a prolonged spell of reading, from that which is found immediately after the eyes have been for long used in distant fixation. Thus there is afforded a good scope for self-deception. The uncritical observer readily accepts any favourable change as a justification of the diagnosis of muscular defect, and of the treatment which he may have adopted for it.

But in the vertical movements of the eyes there are not, as in

the lateral, two differently directed innervations at play. Both eyes move in the same direction upwards and downwards—never in opposite directions. Vertical deviations cannot therefore be due to the persistence of an innervation which does not exist. Their cause and importance must be of a different nature from that of lateral deviations. But do these vertical deviations depend upon purely muscular anomalies? There are, I think, reasons for believing that they do not. There is, for instance, no regular change in the degree of deviation on upward and downward fixation such as must characterise a truly muscular weakness. The movements of the two eyes are, in other words, concomitant. Then, again, it is not so very uncommon to find that the position of rest for each eye, on occlusion of the other, is higher than the plane in which the line of fixation lies. Whichever eye, then, is fixing, the other is rotated upwards behind the occluding hand or screen, and makes a compensatory downward movement when the obstruction is removed. There are also cases in which, when one eye fixes, the other is misdirected upwards; while, when the other takes up fixation and the first is occluded, its deviation is downwards.

These facts suggest another explanation for hyperphoria. And this is strengthened by the consideration of the individual differences which are found to exist in the extent of latent lateral deviations for different directions of fixation. These cannot all be explained as states of innervation or habit alone. Some of them probably depend upon peculiarities and abnormalities in the relations of the adnexa. Similar abnormalities are, probably, the cause of hyperphoria, as there is in this condition nothing characteristic of muscular defects as we know them, and no innervational cause to explain the deviation. Marked changes too, such as take place in the degree of lateral deviations, according to circumstances, to which reference has just been made, are not met with in vertical deviations. This is another reason, if any were required, for excluding innervation, namely, the absence here of instability which is caused by changes in the state of innervation.

As regards the asthenopia to which hyperphoria may give rise, it is evidently due to the difficulty which the relative position of rest of the two eyes interposes in the way of easy fusion. This form of asthenopia, too, is readily and permanently relieved by treatment. In this respect it resembles accommodative asthenopia, and differs from the other forms of so-called muscular asthenopia which have been discussed.

The best treatment is undoubtedly the use of vertically refracting prisms, which neutralise the latent angular deviation. The prisms required can be readily determined by using a Maddox rod in front of the one eye and a prism in front of the other. Generally speaking, unless there are other reasons, such as anisometropia, which render it advisable to place the full strength of the vertically refracting prism in front of the one eye alone, it is best to distribute the prismatic effect as equally as possible over the two eyes. It is only rarely that an operation may justifiably take the place of prismatic optical correction. It is always difficult to get a good correction by operation. I doubt if it is ever possible to get a perfect one. But operation may be tried in cases in which the hyperphoria is very great,—more than 6° to 8°, for instance,—and also in cases where the patient, having otherwise no reason to wear glasses, is specially anxious to avoid doing so. Anything like frequent tampering with the muscles causing vertical rotation is certainly a mistake. In my opinion, too, interference of this kind should be confined to capsular advancement, and the primary effect of this should be an over-correction.

All the forms of asthenopia, with the exception of headaches from astigmatism, may be looked upon as essentially due to some difficulty in maintaining binocular fixation at a reading distance. The existing conditions of refraction, of convergence, or, as in hyperphoria, of the relative positions of rest of the two eyes, may be the cause of this difficulty. A greater than normal effort may thus devolve upon the fusion innervation. But it is evident that the effort of fusion may be greater than can easily be made even in the absence of any abnormalities in these conditions, merely, it may be, owing to general neurasthenia. The symptoms are then the same.

This neurasthenic element should always be kept in view. Otherwise too great importance may be attached to slight deviations from the ideal normal conditions, which in reality have little or no bearing on the asthenopia. More especially should we guard against attributing any etiological importance to the muscles themselves, as the term "muscular asthenopia" is apt to suggest.

These considerations should lead us to avoid, as a general rule, operations on the muscles for asthenopia; but the very real troubles which constitute asthenopia need not be neglected. On the contrary, they call for treatment. The accommodative form and that due to hyperphoria can be permanently, though it may be not always immediately, relieved by convex lenses

in the one case and prisms in the other. In other forms too, glasses (which may often advantageously be tinted), rest, graduated use of the eyes, and suggestion other than by operation, will usually help to modify, if not altogether to remove, the asthenopia.

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